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Technology Review

Edited at the Massachusetts Institute of Technology

HOW TO SAVE A FUTURE ARGO MERCHANT'S OIL

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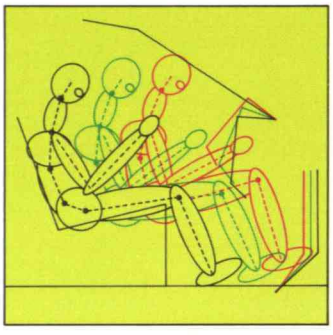

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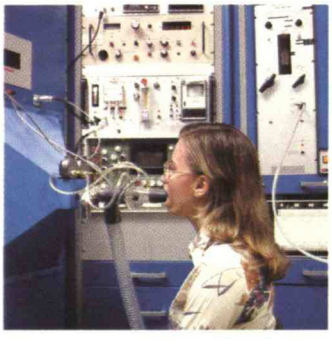

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Technology Review

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The Loch Ness Connection

Though many readers will associate the name of Dennis L. Meredith of *Technology Review*'s Board of Editors with our occasional coverage of the search for the Loch Ness Monster, that's an incomplete association. In two years as Managing Editor of the *Review*, Mr. Meredith's contributions have been wide-ranging in subject and substantial in depth.

So it's with greatest regret that we record his imminent departure, to become Director of the News Bureau at California Institute of Technology. As this is written, Mr. Meredith is once more on the shores of the Loch Ness, from which he will report summer developments for our first fall issue (*see below*); his story of the earlier Loch Ness expeditions was published late this spring (*Search at Loch Ness*, New York: Quadrangle/The New York Times Book Co., 1977, $9.95). It's probable that only after Mr. Meredith's midsummer departure will the Board of Editors, and later the *Review*'s readers, come fully to appreciate his manifold contributions to both the content and style of Volumes 77, 78, and 79. — *J.M.*

Completing Volume 79

This issue of Technology Review completes our 79th volume. The eight issues of Volume 80 will begin in the fall, with a number dated October/November and scheduled for publication on September 30.

D. L. Meredith

Letters

Fuel-Conservative Flight

I am surprised that the U.S. task force has not included among its proposed fuel conservation measures the "canard" configuration, in which the horizontal stabilizer is forward of the wing instead of behind it (*"Fuel Economy in Aircraft Design," October/November, 1976, p. 23*).

The landing condition, which determines the minimum permissable wing area, is characterized by a nose-down moment that results from the rearward travel of the center of lift on deployment of the wing flaps. In the canard, this nose-down moment is balanced by a nose-up lift of the stabilizer, thus reducing the lift required of the wing, resulting in a smaller wing, which has less drag under all flight conditions.

During normal flight there is also usually a nose-down moment balanced by a tail-down load. Thus the combined drag of wing and stabilizer is a function of weight plus twice the down load. With the canard, where both surfaces are lifting, it is only a function of weight.

These effects are sufficiently large to merit consideration. I must therefore ask the task force, "Why doesn't the fuel conservative transport have the horizontal stabilizer in front instead of in the rear?"

Frederick J. Hooven
Hanover, N.H.

Dr. Hooven is Professor of Engineering at Thayer School of Engineering, Dartmouth College. — Ed.

Two simple fuel-saving methods can be put into use at once:
— A speed slow-down of the airplane. It is my impression that even a 5 per cent reduction of speed will be effective in fuel consumption.
— Long-range flight control to prevent holding patterns above airports.

Harold E. Edgerton
Cambridge, Mass.

Dr. Edgerton is Institute Professor, Emeritus, of Electrical Engineering at M.I.T. — Ed.

People-Machine Systems

Though "Literate Computer: A Long Way to Go" (*March/April, pp. 72-73*) was presented as a status report based largely on papers on man-machine systems given at last fall's International Conference on Cybernetics and Society (at a session I organized and chaired), it failed to capture all the important developments reported on that occasion.

Specifically, it ignored completely papers by David P. Himmel of Recognition Equipment, Inc., and Joseph Yacyk of Scan-Data Corp. which were especially included to suggest what had been accomplished to date through a judicious blending of pattern recognition and human factors effort, and how this had in turn permitted the successful commercial application of alphanumeric handprint readers. I believe you did your readers a marked disservice to present Blesser and Shillman's U-V discrimination effort as the latest state of the art.

I also regret that your coverage of Robert S. Apsey's paper was restricted to tests performed on two highly constrained alphanumeric fonts, presenting the human test subjects' unhappiness and low productivity with these fonts as "another small victory for people over machines." Mr. Apsey's paper (and for that matter, the entire session) was specifically organized to describe the extensive work done to produce not a victory for people *or* machines, but rather people-machine systems which could be successfully deployed precisely *because* they took into consideration the capabilities, limitations, and preferences of each. The low-constraint American National Standards Institute handprint font shown in Mr. Apsey's paper (but not in your article) was designed by a team of engineers and human factors specialists to be easily and reliably printed by humans *and* read by machines:

Ø1234567 89+-
ABCDEFGHIJKL

The success of this effort is reflected in the results described by Messrs. Himmel and Yacyk.

A. I. Tersoff
Rockville, Md.

Mr. Tersoff is General Manager of the Electronic Sciences Division, Research and Development Department, U.S. Postal Services. — Ed.

Alternate Directions for Fusion

"Dirty Directions for Nuclear Fusion" (*March/April, pp. 8-9*) points out the two "non-pluses" of the hybrid fusion technology: plutonium breeding and formidable engineering problems. The argument is correct in the sense that the current emphasis on these problems represents the conventional wisdom. For completeness it is worthwhile to mention some appealing alternatives.

First, the plutonium cycle can be replaced by the thorium fuel cycle (Th-232 to fissile U-233); in so doing, many of the plutonium hazards are substantially reduced. Second, the hybrid design concept — which does represent the worst of the fission and fusion world — can be replaced by the symbiotic design concept, which provides for separate fusion and fission reactors joined by efficient isotope exchange linkages.

A. A. Harms
Hamilton, Ontario, Canada

Dr. Harms is Associate Professor of Physics and Engineering Physics at McMaster University. — Ed.

General Principles, Particular Cases

"The minimum wage is a superb example of a wholesale solution to a retail problem, and its effects on human welfare are almost certainly adverse."

Technology/Society
by
Kenneth E. Boulding

Government policy has to be wholesale, while the problems it seeks to solve are retail. The law must address itself majestically to general cases; it cannot pinpoint. An act of Congress cannot say that John Smith at such an address must or must not do such a thing at a given time and on a given date. The law would be unconstitutional. Nevertheless, reality, as William Blake said, comes in "minute particulars," and all minute particulars are unique.

In economic policy, the problem of general principles versus particular circumstances is especially acute. Government wants to encourage economic development. But economic development is in turn the result of innumerable acts by individuals: John has an idea and works up an invention; Richard starts a new firm; Patricia breaks out of the family to go back to college; Sara quits the village and starts a business in town. Government cannot tell any of these people what to do. It can only set up institutions — banks, schools and universities, health clinics, radio stations — and hope that all this will produce cumulative change.

The behavior of individuals depends on their perception of the economic environment. Habit is very strong. The easiest thing to do today is what we did yesterday. The decision to change always implies hope for the future, and hope depends on some degree of stability and certainty. We compare the risk of the known against the risk of the unknown.

How then does government diminish the risk of the unknown? The great case for political conservatism is that a stable government which avoids much excitement or experimentation encourages more individual excitement and experimentation than does an unstable government.

The Price of Wheaties

The difficulty free-market societies have in achieving full employment without inflation is an example of wholesale government faced with an essentially retail problem. The price level (which rises to produce inflation) is a statistical myth. The reality is again in minute particulars: we note the price of a box of Wheaties in a supermarket in Salina, Kansas, against the prices on a million other boxes. This is why price control has always broken down, or else has produced shortages, surpluses, and black markets. We cannot put a policeman on every box of Wheaties. Instead, we must say that prices as of a given date may not be raised without permission. We grant permission by setting up a huge bureaucratic apparatus (like the wartime Office of Price Administration). But the bureaucracy never keeps pace with the continually shifting, subtle conditions that would determine the market price in a free market. Eventually the strains become intolerable and the system breaks down.

In socialist countries, of course, the problem is easier to resolve because individuals enjoy much less freedom to set prices and because people seem willing to put up with time-wasting shortages and queues, so long as the euphoria of the socialist purpose lasts. It is significant, however, that inflation in Yugoslavia seems more severe than in capitalist countries — perhaps precisely because it is the freest of the socialist countries.

Employment and Inventory

The root cause of unemployment lies in the labor market. It is extraordinary that economists are so unwilling to recognize this, and so ready to dismiss the exchange aspect of employment. Even common language reveals this: we talk about "giving" employment as if it were part of the grants economy. In fact, people very rarely "give" employment, though they may give volunteer services. An employer hires an employee because the employer thinks the wage a good trade for services, and so presumably does the employee.

The first effect of hiring is to diminish the stock of liquid assets and increase inventory, which is an immediate measure of the product of the work. The willingness to hire, therefore, depends at least in part on the state of the inventory; if inventory is piling up, the employer is less willing to hire. The economist's wholesale approach — such as President Carter's ill-fated $50 per taxpayer — is to put money in the hands of consumers and hope that they will spend it, diminish business inventories, and hence create incentives for hiring workers to replace the inventories. The trouble is that the wrong inventories may be sold and their prices raised, and so the effect is inflation rather than employment.

An Underworld Colloquy

Intervention in the labor market, however, is even more difficult than in the market for commodities; wage control is harder to achieve than price control. The minimum wage is a prize example of the delusion that employers "give" employment and will continue to do so at any wage. Instead, the minimum wage almost certainly creates unemployment among those least able to bear it — the young, blacks, women, and the really poor. This is not to deny the need for occasional legal protection against employer monopolies (or monopsonies). But the minimum wage is a superb example of a wholesale solution to a retail problem, and its effects on human welfare are almost certainly adverse.

How, then, do we intervene in the labor market? How do we persuade a particular employer to hire? The obvious solution is some kind of subsidy. But how do we administer a subsidy over millions of cases? Economists have simply chickened out on this problem, which is perhaps why in 30 years we have failed to solve the unemployment-inflation dilemma.

Some ideas are emerging from the amateurs, which is perhaps their only reasonable source. Richard Hazelett in Greeley, Col., proposes "work incentive contracts" in the form of marketable subsidy to employers who increase their labor force. Gifford A. Young in Washington has an idea to use information now collected by the Department of Labor for its hiring projections. Such notions circulate in an underworld to which I confess I secretly belong. And I rashly invite anybody else who belongs to it to write to me, because I think something is emerging — something we have not yet thought of, or thought through. It is a solution, I suspect, that will seem absurdly simple when we do think of it.

Continued on p. 80

Breadline Budgets Weaken U.S. Science and Technology

"The nation is faced with the possibility that it will lose scientific and technological leadership in many fields."

Washington Report by Colin Norman

Support for basic research in the U.S. has shrunk as inflation rises faster than federal funding. And the financial difficulties facing academic science have been compounded by the steeply deteriorating budgets of universities, given escalating costs, dwindling student enrollments, and shrinking support from a variety of sources. Moreover, the stiff competition for research grants, coupled with a number of complex federal regulations, have placed increasingly heavy administrative burdens on the scientists in charge of the nation's large university laboratories, cutting into their research time and decreasing their productivity.

Assertions such as these appear on cue each year when scientists testify before Congress in support of budget increases for basic research, and they compose a litany in science reports and publications. But what is the evidence that American science actually suffers from financial and administrative burdens? American scientists, after all, made a clean sweep of last year's Nobel Prizes, the scale and vitality of the nation's research enterprise remains impressive enough to attract the envy of most scientists elsewhere, and science has not been treated any more harshly than other programs in ths federal budget.

A report published early in June (*The State of Academic Science,* Change Magazine Press, New Rochelle, N.Y.; $5.95) helps explain the apparent paradox that while support has diminished, quality has not. Written by two social scientists, Bruce L. R. Smith of Columbia University and Joseph J. Karlesky of Franklin and Marshall College, the report's chief message is that the universities have largely maintained the productivity and vigor of their laboratories by putting off the purchase of new instruments and facilities; by cutting back sharply on new faculty hiring; and by reducing their research support services. Consequently, "the evidence of deterioration in the underlying infrastructure for science is now extensive," Drs. Smith and Karlesky write.

While these economies have so far prevented major disruptions in research efforts, they cannot be maintained for much longer without serious damage. "The discoveries that are now being made are based on research initiated many years ago," according to the authors of the report. The system is operating only on "the strong momentum generated during World War II, and for 25 years thereafter." As a result, "An important national resource may be eroding and the nation is faced with the possibility that it will lose scientific and technological leadership in many fields."

Perhaps the most detailed study of the health of academic science yet produced, the study was financed by the National Science Foundation (N.S.F.) and published with the help of a grant from the Alfred P. Sloan Foundation. It is likely to be quoted often in the next few months as Congress considers the budgets for N.S.F. and other science agencies, and as the fledgling Office of Science and Technology Policy begins to examine the organization and health of the nation's research enterprise.

Obsolescence and Disrepair

Drs. Smith and Karlesky begin by citing a sheaf of statistics depicting the declining fortunes of academic science. Federal support for basic research in the universities, measured in constant dollars, dropped by some 9 per cent between 1968 and 1976, and at the same time it changed dramatically in character. A decade ago, nearly half of the federal research funds spent in the universities was in the form of flexible institutional support, such as graduate fellowships, block grants to strengthen scientific facilities, and so on. But last year, less than 20 per cent of federal support for academic science came in that form. The bulk of university research is now funded through direct project grants and contracts, many of which are for "targeted" studies. "Less discretionary money is available for departments to 'fill in the gaps' and tide investigators over periods of uncertain support for their work," Drs. Smith and Karlesky report.

A significant impact of this decline in support and the switch to less flexible funding is that instrumentation in the nation's academic research laboratories is becoming outdated and in disrepair. Drs. Smith and Karlesky state that numerous university administrators and heads of departments now worry about updating equipment, keeping instruments in good repair, and replacing obsolete equipment. In one midwestern university, for example, no funds have been provided for the purchase of new instruments for six years.

As for graduate enrollment, between 1968 and 1975 enrollments in physics declined by 30 per cent, in chemistry by 21 per cent, and in mathematics by 31 per cent. Enrollments in the life sciences and social sciences have, however, continued to expand. Coupled with those trends is the decline in academic job opportunities for young aspiring faculty. Many universities have been forced to make drastic cut-backs in new faculty hiring, so that existing faculties are aging and predominantly tenured. This obstacle to new talent for academic research "will be one of the most serious threats to the momentum of university research over the next decade," Drs. Smith and Karlesky predict.

Research or Teaching?

One of the major findings of the study is that the most prestigious departments and universities have largely maintained their strong positions, while second-rank institutions and departments are struggling to attract both funds and good graduate students. As a result, Drs. Smith and Karlesky warn that some weaker universities may be forced to drop graduate courses or abandon some research programs. Academic science would then become increasingly stratified, with fewer universities and departments conducting important research over a broad spectrum of disciplines.

A university facing dwindling enrollments in some courses would be faced with the painful choice of either continuing with a research effort in the absence of graduate students or de-emphasising research to concentrate on undergraduate teaching. Both choices would represent a significant departure from the traditional close links between research and graduate teaching, and they would inevitably force a re-examination of the nature of graduate

Continued on p. 75

World Thirst for Pure Water

"Nearly all the pollutants the world discharges into the air end up in its water systems."

National Report
by
David F. Salisbury

"Water, water, everywhere nor any drop to drink," lamented the Ancient Mariner in his famous rime.

Samuel Coleridge penned these lines late in the 1700s, and now they are assuming a new currency. Concern is gradually spreading among world leaders that a period of widespread water supply problems approaches.

At the United Nation's water conference held in Argentina last April, there was a consensus that vigorous steps must be taken "to avoid a water crisis of global dimensions within the next few decades." Although the world has ample supplies of raw water — some 326,000 cubic miles of it — the developing crisis is one of local shortage and poor quality.

Ninety nine per cent of the world's water is in the oceans, or is locked in the ice. At any given time, only 0.7 per cent of the world's water supply is fresh. And only one-sixth of this amount is gathered into streams, rivers, and lakes. The remainder seeps into underground reservoirs and watercourses.

The absolute quantity of fresh water, however, is not so important as the rate at which it is replenished. Roughly 28 per cent of the world's water is purified yearly by evaporation. One quarter of this falls to the land as rain, sleet, and snow to be potentially available for use.

Liquid Economics

By current estimates the world population will require about 25 per cent of the annual flow of all earth's surface waters by the year 2000. But the cost of water begins rising rapidly when more than 10 per cent of the total supply is exploited in a given region. In fact, "if water demand exceeds 20 per cent of total runoff in the area under consideration, questions of water supply can be described as the absolute limiting factor of economic development," argue Malen Falkenmark and Gunnar Lindh, Swedish water experts. "In other words," they say, "water management plays such an important part in the economy of a country or area that it completely dominates economic planning."

Asia has already passed the 20-per-cent mark, while Europe and Africa should approach it by the end of the century, Drs. Falkenmark and Lindh calculate. The drought in the Sahel, and current water shortages in the U.S., Europe, and China bear witness to the likelihood of these statistical predictions.

"To this day, 'water' is the anguished cry of millions," says Laetitia Obeng, a Ghanaian biologist working with the U.N. Environment Programme (U.N.E.P.). "Lack of water has changed once-fertile soils into sands and dusts which rise and fly . . . once-luxurious shrubs and vegetation wilt and droop, and one-time graceful gazelles and dependable camels thirst and die. . . ."

Drought is the most dramatic aspect of the coming crisis. But equally important is the growing rate at which water is polluted by a burgeoning world population. "Impure water is the major hazard at present, not scarcity," says Noel Brown, the Jamaican U.N.E.P. liaison officer in New York.

Each year some 10 million deaths are directly attributable to waterborne intestinal diseases. And more than one third of humanity labors in a state of continual debility as a result of impure water. Parasitic diseases, such as schistosomiasis which now infects some 250 million people in 71 countries (according to W.H.O. estimates), are often spread by water development projects and are difficult to control. A pure water supply can slash the incidence of cholera, diarrhea, dysentery, and typhoid by 25 to 75 per cent, according to studies done in Japan, the Amazon basin, and Uttar Pradesh in northern India. The World Health Organization calculates that supplying potable water is by far the most cost-effective health measure which can be taken.

Because of heightened consciousness about the seriousness of the water problem, the "family of nations" has pledged $21 billion between now and 1980 to provide safe water. The World Bank meanwhile estimates that it would take about twice that sum to eliminate most of the planet's water problems; the cost could be recouped in increased pro-

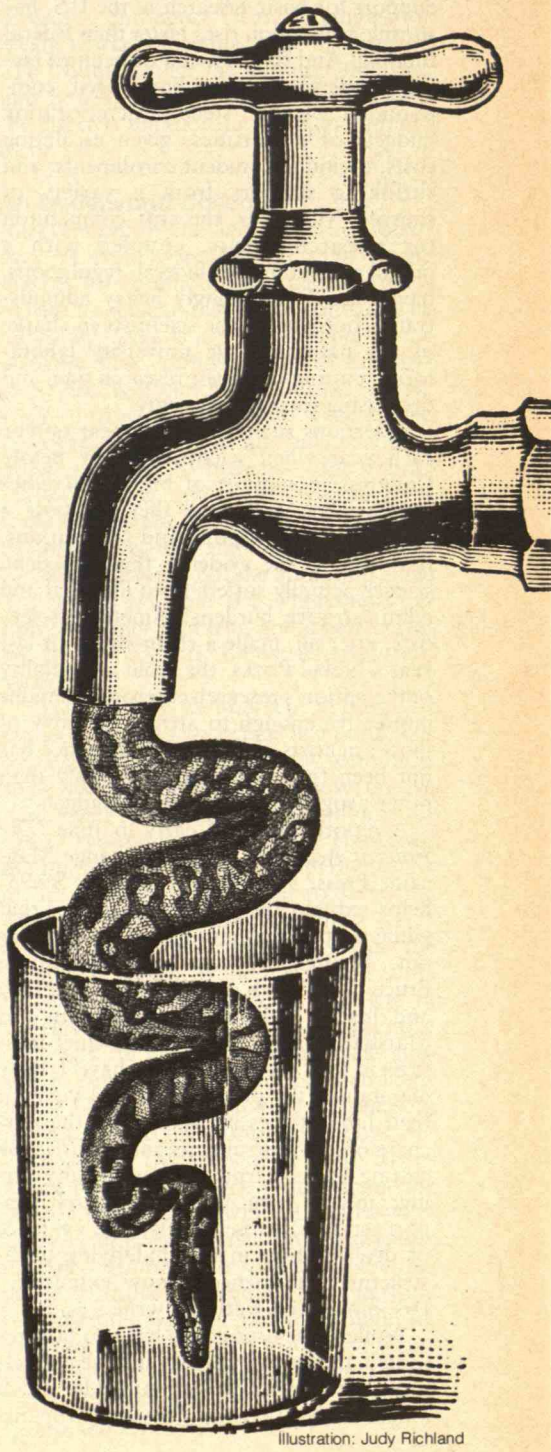

Illustration: Judy Richland

ductivity and reduced medical expenses in five to ten years. Erik Eckholm of Worldwatch and other critics argue that the number of people who live without easy access to "safe" water — 1.2 billion in the developing countries except China — remains scandalously large, despite the progress that has been made since 1950.

Don't Drink the Water

As tragic as the situation is already in many developing countries, Norman H. Brooks of the California Institute of Technology warns that it can become even worse. The proliferating chemical cornucopia being produced in the industrial countries threatens a still more severe ecological disaster.

Some 30,000 chemicals are now in commercial production. Each year about 1,000 new compounds are added. Some can be lethal in minute quantities. Only about 10 per cent have been tested for carcinogenicity.

Not only the chemicals dumped directly into streams, rivers, and lakes are cause for concern. "Nearly all the pollutants the world discharges into the air end up in our water systems," as well, Russell W. Peterson, head of New Directions, reminds us. "After falling on the land, the rainwater picks up fertilizers, pesticides, and silt from farms; it picks up acid from strip mines and oil from the highways and streets; it picks up a great diversity of chemicals from industrial and commercial establishments. . . ."

As a result, drinking water is the most unreliable commodity in the U.S., says John Wood, Director of the Freshwater Biology Institute in Minnesota.

In July, the nation's latest Safe Water Drinking Act went into effect and should help correct this situation. And after a five-year fight in Congress, a Toxic Substances Control Act was passed last year. Although this legislation places the burden of proof for a chemical's harmful side-effects on the government, it ought to give some relief.

The environmental consequences of chemical pollutants are more mysterious and more difficult to determine than toxicity or carcinogenicity. But there are disturbing indications that trace amounts of some chemicals spread throughout the environment may have long-term adverse effects.

Petroleum, mercury, and polychlorinated byphenyls (PCBs) in parts per billion change the relative populations of diatoms and dinaflagellates, the algae which form the foundation of the aquatic food web. Juvenile coho salmon experience abnormal weight gains when fed PCBs in parts per million. The insecticide malathion inhibits algal growth. Dieldrin in parts per billion made several species of fish unable to withstand slight changes in temperature. And so on.

Further, Robert Harriss of Florida State University, cautions, "I am afraid that the laboratory tests of the effects of pollutants understate the case. For these experiments take place under ideal conditions: the animals have ideal growing conditions; they are not under multiple stress as is the case in the wild."

In sum, our attitude toward the water cycle as a convenient sewer for our wastes may soon have devastating effects, if it hasn't already.

"The basic lesson to be learned from mankind's various water-related misadventures," says Mr. Peterson, "is that water is not a mere passive resource, to be extracted and developed as we see fit; it is also a dynamic force pursuing its way from the skies, across the land, and back to the sea in watercourses that were ancient before man emerged on the globe. We must learn to respect its function as an integral component of our earth processes, and to accommodate ourselves to that function. When we do so, water is a vital force for human betterment; when we do not, it is a terrible force that can destroy and debilitate human lives and human settlements."

David F. Salisbury is West Coast correspondent for the Christian Science Monitor *and a regular contributor to the* Review.

Hanging Together: International Energy Strategies

"No country has a special advantage with O.P.E.C. in the long run; only internationally coordinated energy planning will make sense as oil supplies tighten."

Science Report
by
Robert Cowen

Carroll Wilson is Project Director of the Workshop on Alternative Energy Strategies (W.A.E.S.) which has warned of a global energy shortage. Dr. Wilson recounts an amusing vignette that illustrates how naïve supposedly sophisticated energy planners have been in preparing for the future.

As Paul Basile and David Sternlight explain in their summary of W.A.E.S. for the *Review* (*see June, pp. 41-49*), the two-year, 15-nation project was carried out by national teams that included academic, industrial, and governmental experts, acting as private individuals but well informed of their respective national energy plans. When they met as a committee of the whole, Dr. Wilson says, he would ask each team for its latest national energy projection. Invariably, after allowing for "sensible" conservation and more reliance on alternative fuels, there would be a residual need to be met by importing oil. Add up those expected imports and, invariably, they would come to more than the non-Communist world oil production could be expected to supply 10 to 20 years hence.

Each nation thought it had some special advantage in getting its oil when such shortages developed. The Italians might say they had earned the gratitude of Arab producers by helping to install petrochemical feed stock equipment. They quite ignored official O.P.E.C. statements that oil production ceilings may be imposed in order not to flood Arab economies with more money than they could absorb as world oil demand rises. Likewise, the Danes might say they rely on their friends the Norwegians to keep sending them North Sea oil. But the Norwegians would point out that they too will limit production to produce manageable levels of cash flow.

In short, Dr. Wilson says, W.A.E.S. teams found that their national energy planning, carried out individually, harbored dangerous assumptions about the future benevolence of the international oil market. They had to face the fact that no country has a special advantage with O.P.E.C. in the long run; only internationally coordinated energy planning will make sense as oil supplies tighten. This is the most significant finding of W.A.E.S.

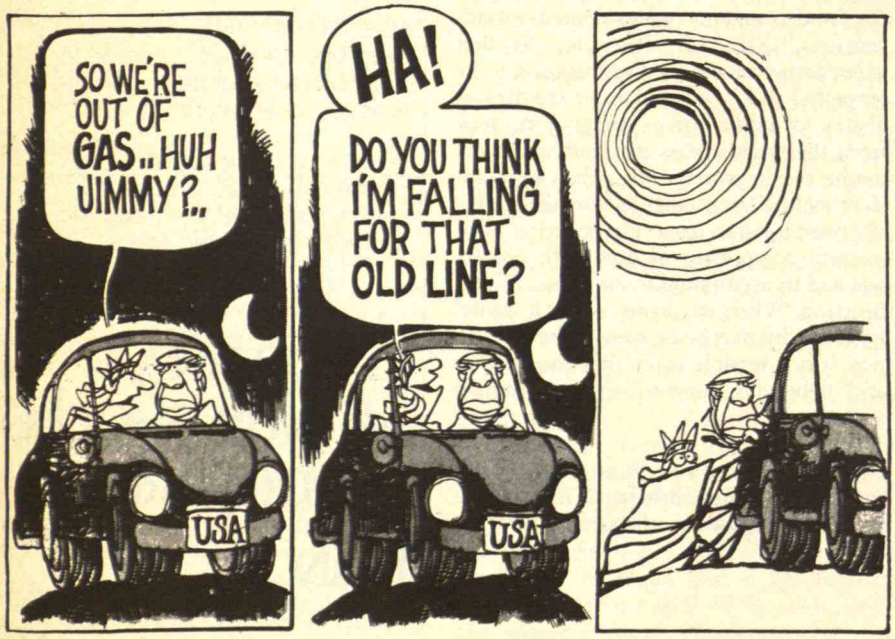

Illustration: Mike Peters; United Features Syndicate

Wartime Urgency

Sometime between 1985 and 2000, probably sooner rather than later, world oil production will fail to meet the projected collective need of non-Communist industrial nations. For this reason, and because of the long lead times needed to implement conservation and use of alternative fuels, W.A.E.S. believes those nations must move away from dependence on oil as their principal fuel, with "wartime urgency." Dr. Wilson says he doesn't think any present national plan, including the Carter energy package, is adequate to accomplish the goal.

In fact, no nation can avoid dependence on O.P.E.C. without international coordination. "The critical interdependence of nations in the energy field requires an unprecedented degree of international collaboration . . .," says W.A.E.S.

Coal illustrates the point. It is the main alternative fuel and, for all practical purposes (outside the Communist countries) the United States is the O.P.E.C. of coal. It will be hard enough for the U.S. to meet President Carter's goal of nearly doubling coal production to around a billion tons a year by 1985 to meet needs at home. Will the country be willing to invest billions of extra dollars and strip thousands of extra acres to send coal to its friends? Japan, in particular, will become critically dependent on American coal if it abandons oil. Coal could become a major foreign policy challenge and a bitter domestic issue for the U.S., Dr. Wilson says.

No Doomsday Forecast

Unfortunately, neither these larger issues nor the W.A.E.S. study itself has received the kind of press coverage it deserves since the report was released in mid-May. Press accounts tend to misinterpret the findings as a prophecy of doom. They are not; W.A.E.S. members emphasize that theirs is a call for action, not a cry of despair.

The report is no "Limits to Growth" plea for adoption of a non-industrial life style. That study has come to be regarded as simplistic and biased in the sense that the authors' preference for the simple life colored both their assumptions and conclusions.

But the W.A.E.S. study report does plead urgency. The Workshop concluded that action must be initiated soon if it is to influence energy postures a decade or more hence. Its report emphasizes the subtle nature of the challenge in that action must be taken during a period when no particular energy pinch is felt. However, it wisely points out that by the time energy shortages pinch, it will be too late to take compensating action easily. The remedy then may be harsh restrictions or economic dislocations. It is this sort of crunch against which the report warns. But it does so without predicting the end of western civilization or the demise of industry.

You can also fault the study for neglecting energy-rich Russia and China. But how would you account for them? Their resources and future prospects are not at all well known on the outside. They may well require all their future increased energy production for themselves, as W.A.E.S. assumes. Indeed, the C.I.A. forecasts Russia to be an energy importer in the 1980s. And what western energy planner would want to rely on Russian or Chinese supplies? Neglecting them in this study does seem rational.

The study has also been criticized as simplistic because it involves somewhat arbitrary economic and resource assumptions. Such criticism misses the project's point. As Mssrs. Basile and Sternlight point out, the economic scenarios are indeed somewhat artificial. But they are not intended as forecasts of the future, only as indicators of trouble when you carry present energy planning to its logical conclusion, using a range of assumptions as to economic growth and development of energy resources that seem rational in light of present knowledge.

What is not at all artificial about W.A.E.S. is its reflection of responsible national thinking about energy. Fifteen national teams put their best efforts into charting their respective national energy futures. They conclude that we will have to make substantial efforts to reduce dependence on oil — efforts exceeding any foreseen up to now. Moreover, they conclude that we must coordinate our efforts to an unprecedented extent. None of us can go it alone in the long run.

Critical Interdependence

Consider the following main conclusions of W.A.E.S. and see if you find them alarmist or simplistic.

— The supply of oil will fail to meet increasing demand before the year 2000, most probably between 1985 and 1995, even if energy prices rise 50 per cent above current levels in real terms. Additional constraints on oil production will hasten this shortage, thereby reducing the time available for action on alternatives.

— Demand for energy will continue to grow even if governments adopt vigorous policies to conserve energy. This growth must increasingly be satisfied by energy resources other than oil, which will be progressively reserved for uses that only oil can satisfy.

— The continued growth of energy demand requires that energy resources be developed with utmost vigor. The change from a world economy dominated by oil must start *now*. The alternatives require 5 to 15 years to develop, and the need for replacement fuels will increase rapidly as the last decade of the century approaches.

— Electricity from nuclear power is capable of making an important contribution to the global energy supply although worldwide acceptance of it has yet to be established. Fusion power will not be significant before the year 2000.

— Coal has the potential to contribute substantially to future energy supplies. Coal reserves are abundant, but taking advantage of them requires an active program of development by both producers and consumers.

— Natural gas reserves are large enough to meet projected demand provided the incentives are sufficient to encourage developing extensive and costly intercontinental gas transportation systems.

— Although the resource base of other fossil fuels such as oil sands, heavy oil, and oil shale is very large, it is likely to supply only small amounts of energy before the year 2000.

— Other than hydroelectric power, renewable resources of energy — e.g., solar, wind power, wave power — are unlikely to contribute significant quantities of additional energy during this century, although they could be important in particular areas. They are likely to become increasingly important in the 21st century.

— Energy efficiency improvements, beyond the substantial energy conservation assumptions already built into the analysis, can further reduce energy demand and supply. Policies for achieving energy conservation should continue to be key elements of all future energy strategies.

— The critical interdependence of nations in the energy field requires an unprecedented degree of international collaboration in the future. In addition it requires the will to mobilize finance, labor, research, and ingenuity with a common purpose never before attained in time of peace; and it requires it now.

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A Thrifty Man's Dilemma

Technology/Environment
by
Ian C. T. Nisbet

"By refraining from buying products which we regard as damaging, environmentalists are accused of slowing economic growth and increasing unemployment."

Almost every action we take, from lighting a cigarette to choosing a career, has an impact on the interests of others by depleting natural resources, polluting the air or water, contributing to the burden of solid waste, or disrupting privacy or economic security. Although most people make decisions about everyday matters primarily for reasons of economy or convenience, those who are sensitive to the interests of others will modify their behavior accordingly.

Of course, what one individual chooses to do (or refrains from doing) has little direct effect on society and the environment. But by the same token, nothing very effective can be done to modify society without voluntary changes in life-style. One goal of environmentalists is to set an example by living in a style which minimizes damage to the interests of others. It is remarkable how much one can achieve in this way without significant inconvenience. My own contribution to environmental pollution and resource depletion is less than half — probably less than a quarter — of that of the average U.S. resident. If everyone were to adopt the same life-style, the crises of energy, resources, and environment might not disappear, but they would certainly become less pressing.

Public Benefit and Private Gains

The central feature of "environmental living" is consumer choice — the selection of products with low environmental impact and the selective avoidance of products with high resource costs or potential for pollution. Frugality is a contemporary virtue — not for old-fashioned puritanical reasons, but because frivolous consumption and waste damage the interests of others. It is no accident that most of the measures that environmentalists promote to benefit society as a whole also save money. Thrift in itself is not a contemporary virtue, but it is important nonetheless. Environmentalists for the most part sacrifice a little private convenience to achieve public benefit, and we enjoy private economic gains as a result.

These private economic gains, however, raise a double dilemma for those of us who practice frugality. In the first place, we are accused of undermining the progress of consumer society: by refraining from buying products which we regard as damaging, environmentalists are accused of slowing economic growth and increasing unemployment. Second, the money we save must either be spent (on consumer goods) or invested (to expand the economy to produce more harmful products).

The accusation is easily answered. It is absurd to argue that all consumption is socially beneficial. Some products such as handguns, cigarettes, heroin, or motorcycles cause damage which most people agree outweigh their benefits. Society as a whole would be better off if these goods were not sold, even if their manufacturers had to join the ranks of the unemployed.

The fallacy underlying the accusation is the implicit assumption that all economic activity is equally beneficial, however damaging or wasteful it may be. Environmentalists do not simply refrain from buying consumer goods. Frugal living implies *selective* consumption: choosing products with low resource costs and low environmental impact, and avoiding the others.

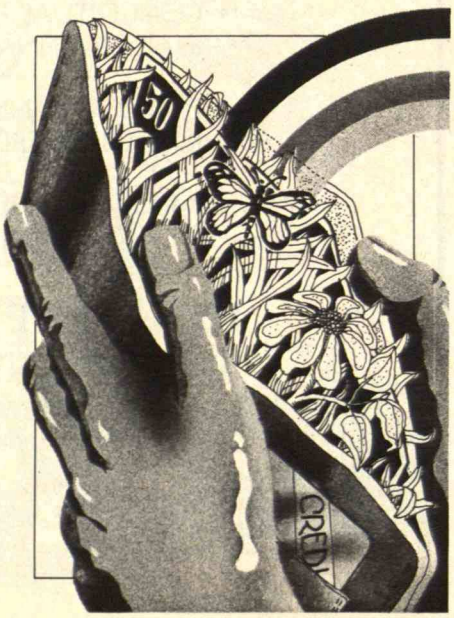

Illustration: Vaughn McGrath

Computers vs. Blenders

The second part of the dilemma is not so often addressed. Environmentalists save money by conserving energy, by buying durable goods, and by minimizing use of damaging products. But what should we do with the money we save? Few of us have the opportunity to invest in environmentally beneficial industries because the structure of the economy places most of these industries at a competitive disadvantage. If we invest our savings in the bank, the bank will in turn invest our savings in conventionally profitable activities. Since the goal of environmentalists is to change the *structure* of the economy, the money saved by selective choice must be used in ways that run counter to the conventional forces of the marketplace.

The answer to the first part of the dilemma helps us to find a solution to the second. Environmentalists seek to buy products whose social benefits exceed their social costs. Money saved in this way is better spent buying more of such goods than ploughed back into the conventional economy to support production of wasteful products. Fortunately, several present-day trends in technology promise to reduce net environmental impact. Miniaturization of electronic components is probably the best example, since it simultaneously offers a reduction in the materials and energy requirements of products, an increase in reliability and performance, and the potential social benefits to be derived from improved communications and access to information. So thoughtful environmentalists spend their money on computers or solar energy conversion, rather than on automobiles or electric appliances.

But the interests of environmentalists are not limited to selection of goods. We are prepared to spend more for goods that are reliable and durable, and we are more willing to spend money on repairs and service than on replacements. In general, environmentalists seek quality rather than quantity, and we prefer handmade goods to mass-produced consumer items. It is no accident that the economic activities favored by environmentalists thus tend to be

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An Industrial View of Energy Planning

"There are only four strategies that will affect our energy outlook for 1985 and 2000 in a major way."

Special Report
by
Edward O. Vetter

The growing imbalances of supply and demand for energy in our economy are not a discovery of the current administration. Previous presidents and several industry groups have been warning for years that we were driving over the cliff. But the winter of 1976-77 gave an effective background to President Carter's program which was formally outlined on April 20, and he deserves much credit in seizing this leadership opportunity. Indeed, the overwhelming publicity and attention given to America's energy problem in the past two months is a classic example of an idea whose time has come.

All elements of our society bear responsibility for our energy dilemma — the government, the energy industry, special-interest groups including the environmentalists, and the public. The solution must be equally comprehensive in its impact, and it will require all of our commitment and skill. We are so overweight, like the 350 pound man who's 5 ft. 2 in., that getting back into shape, in itself, is a delicate and perhaps dangerous task.

And it cannot be achieved overnight. The reality of lead time means that the development of alternative energy sources to levels of production comparable with those on which we now rely will take the bulk of the remaining years in this century. Many have advocated a massive "Manhattan Project" approach, but that represents an oversimplification of both the problem and the available solutions. Our strategies must be flexible, our requirements are enormous and continuing, and our needs must be met — as much as possible — within constraints of our economy (at reasonable cost levels) and life style. The job must be tackled with urgency, but we cannot expect miracles.

An energy plan for the United States must be conceived in terms of two moments in time. One is the year 1985, chosen because until then we are almost locked into present energy sources and, almost to the same extent, demand patterns. The other is the year 2000, when initiatives taken in the next few years might reach full fruition to change our patterns of supply and demand.

There are only four strategies that will affect our outlook for 1985 and 2000 in a major way:
— Conservation;
— Optimal development of domestic oil and gas resources;
— Optimum conversion to coal;
— Optimum development of nuclear energy.

Other programs are worthy and should be pursued. However, these are the only ones that will have *major* impact in this century; these deserve the bulk of our strategic effort.

There are two additional strategies that will play an important role in the year 2000 and beyond:
— Development of such alternate (exotic) energy sources as solar and geothermal;
— Increasing reliance on new systems, such as cogeneration, for achieving major increases in the efficiency of fuel and/or energy utilization.

Conservation: Goals vs. Realities

The early criticism of President Carter's program has been that it has concentrated too much on conservation and not enough on production increases and fuel substitution to reduce the demand for imported fuels. Indeed, the program as outlined to date is out of balance. We should in fact give almost equal weight to all four strategies first listed, even though each does not achieve equal results in reducing energy demand or providing new supplies.

The current energy plan is most specific regarding conservation, and this is perhaps where our greatest opportunity lies. However, conservation goals are meaningless unless they are indexed to expectations of population and gross national product. My own judgment is that the results from President Carter's conservation initiatives will fall considerably short of those theoretically possible. This is because conservation is the most painful of all strategies, so the legislation proposed by the administration will be watered down and the public will respond slowly.

It is a classic case of preaching vs. meddling. As long as we talk in generalities of how wasteful we have been, we are preaching — an approved practice. But when we come to the point of reducing wastefulness with specific taxes (or "disincentives" in bureaucratic lexicon), those affected see us as "meddling" in their business, and then the protests arise.

Nevertheless, conservation must be rated high on our priority list for the period from now to 1985. But we must recognize realities: large families require family-size cars (suddenly termed "gas guzzlers"); widely dispersed communities with no public transportation, particularly in our growing southern and western states, are dependent upon automobiles; and significant conservation initiatives have already been taken since 1972 under incentives provided by increased energy costs and programs adopted by prior administrations.

An Environment for Risk-Taking

The current plan is less firm about our other three strategies: domestic oil and gas development, optimum conversion to coal, and optimum development of nuclear energy. The right words have been said, but few specifics are provided. Furthermore, execution of all of these strategies is constrained by a maze of regulatory shackles, and the legal stalling tactics of special-interest groups will continue to stifle aggressive action even though the need is compelling and the economics attractive.

President Carter should launch a "media blitz" of the magnitude displayed in connection with the program announced on April 20, to eliminate arbitrary and unbalanced regulatory requirements which constrain energy production and conversion initiatives. It is unfair for one sector of our society to pay unnecessarily high energy prices because another sector unreasonably withholds the opportunity to increase energy supplies.

Oil and gas are the most readily useable of all our energy sources, and they are especially important for that 25 per cent of our energy use devoted to transportation. Long lead time is required to expand the use of coal and nuclear fuel and to convert end-users from oil to other forms of energy. Indeed, all the nuclear power plants which can be on-line by 1985 are

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Outposts of Progress

Special Report by John Holt

Advocates of space colonies have been making some outrageous claims to justify their proposals. But even if we can actually accomplish on the moon or in space all the things the advocates suggest, space colonies will remain wasteful, unnecessary, and dangerous.

Take first the matter of self-sufficiency. The space colonizers claim that in a short time, and with only 10,000 or so inhabitants, space colonies could be self-sufficient. To test this claim, let us ask ourselves what on earth's surface is the least population that a nation, having within its borders all the resources needed for a modern economy, could have and still be completely self-sufficient? An optimistic guess would be about 10 million; certainly Norway, with a population of 4 million, could never manage it. Let us then ask how much more complicated, how much more technically demanding, would life in space be than life on earth? Here a very optimistic guess would be two or three times more — even assuming (which is a great deal to assume) that we could secure all the needed resources by mining the moon and/or meteorites, or by growing them in special agricultural satellites.

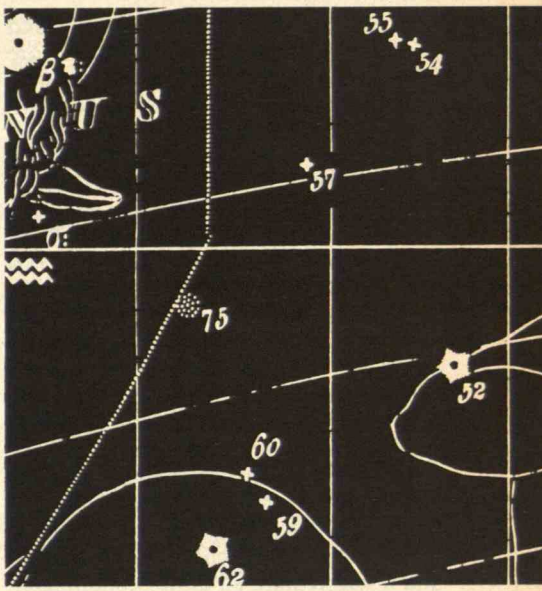
It follows, then, that a space colony or group of colonies, in order to be wholly self-sufficient, would need a population of not less than 20 or 30 million. Even if we had 10,000 people living and working in space right this minute, to bring the population of that settlement up to 20 or 30 million would be the work of the best part of a century — and while it was going on, most of the needs of that settlement would have to be met by earth. Such economic effort would utterly exhaust and bankrupt any nation, however rich, that tried to do it.

Perpetual Motion

Consider the colonies themselves, as structures. All the literature about space colonies suggests very strongly that once we get the things built and set out in space where we want them, spinning at the right speed, they will run forever. But a human habitation in space is a *machine.* Machines wear down, wear out. They have to be checked, overhauled, repaired, replaced. More specifically, a human habitation in space is a *ship,* indeed a submarine, but in an environment even more dangerous, deadly, and unforgiving of mistakes than the deep waters of the ocean. The lives of everyone in any human habitation in space (or on the moon) will depend on the constant and proper working of a host of systems — mechanical, electrical, and biological. If any one of these breaks down for very long, some people, and most probably all the people in that habitation, will die.

Here on earth, when we want or have to use machines such as aircraft or submarines that will kill us if they fail, how do we make sure that they don't fail? The answer is, we fix them first, long before there is any danger of failure. We put them on very rigid maintenance schedules; after every so many hours of use, we take them out of action, strip them apart, test, check, measure, and if need be replace every part, wire, valve, and pipe within them, and then return them to service. And even with this sort of maintenance, machines are not, so to speak, immortal. Very few planes or submarines see more than 40 years of active service, and even surface ships, where the danger of failure is less immediate and urgent — the margin of error greater — seldom have active lives of as much as a century.

When we repair a ship or a plane, we bring it to shore or into a hangar, send the crew off somewhere else, and work on the ship or plane until it is ready to go back into service. How could we do this with a space submarine? Where would the people go while their spaceship was being overhauled, checked, repaired, made good as new? Are we being asked to suppose that these giant space ships will in all respects be able to repair themselves? To do this, they would have to have at least two of every important system they carry — able to work independently of one another — so that while routine maintenance was being done on one the other could work in its place. Two might not even be sufficient; three would be much safer. Of course, the proponents of space colonies do not ask such questions; in all the considerable amount of literature I have read, I have yet to see any talk about machines being *fixed.* In that sense, the space colonizers seem to believe in perpetual motion.



Deus ex Machina

How would we make checks, or repairs, on the *outside* of a spinning body? And in what sort of facility would these repairs be made? Planes are repaired in giant hangars, ships in huge drydocks — for the repair of these machines requires machines as big as they are, much too big to go inside them. In what sort of hangar or drydock would we repair — or in the first case, build — a mile-long spaceship? And how would we protect the atmosphere inside them when we were overhauling and repairing the hull, or even the airlock doors? A door is a machine. Like any machine it wears out in time, and so must be checked and repaired so that it does not wear out unexpectedly, when we can't survive it.

The answer is, of course, that we would lock the inner airlock doors while overhauling the outer doors, and vice versa. But this means that while the doors and their associated electrical, hydraulic, and mechanical systems were being fixed, all

"Even if the space colonizers can do what they promise — and they can't — we hardly know how to eat and sleep in zero-gravity, let alone mine, smelt, and manufacture."

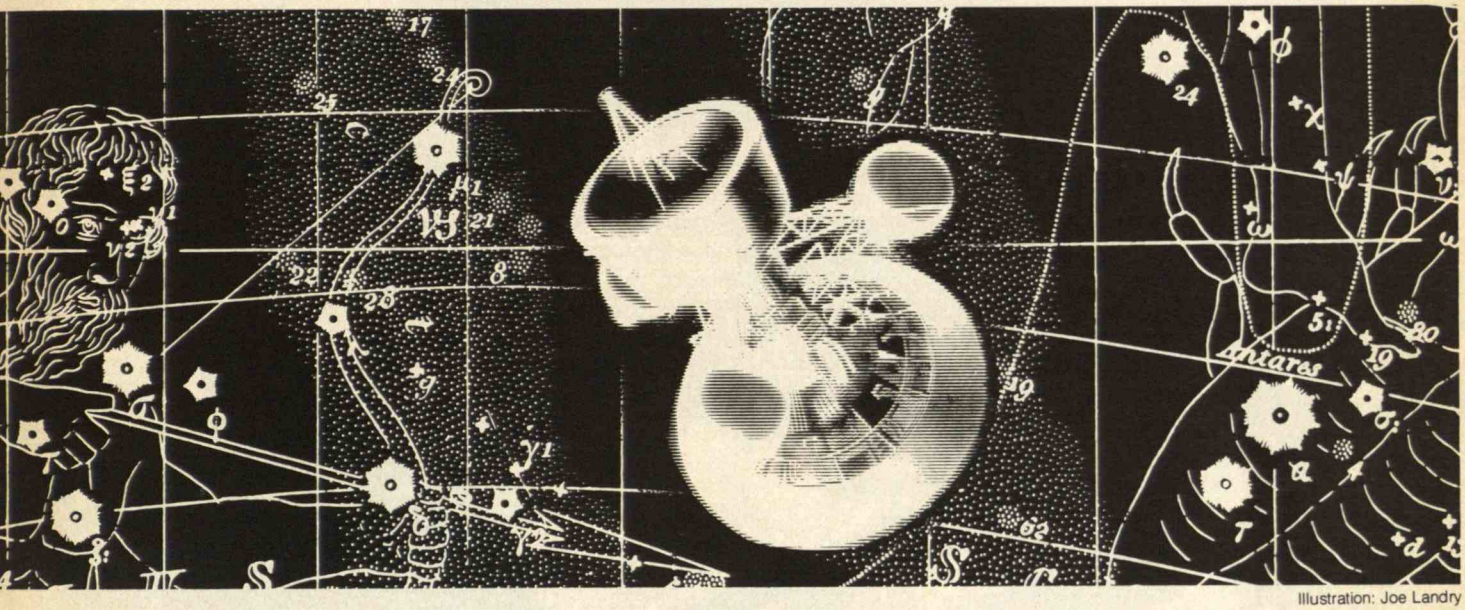


Illustration: Joe Landry

traffic would have to be routed through the other airlock. (For a moving spaceship, there are only two stationary points on the axis of rotation where doors might be located. The difficulty of docking a spaceship in a moving airlock makes only two airlocks feasible.)

How large can a human settlement be that can receive all its necessities, do all of its comings and goings, send large numbers of people out every day to work in its factories, take in all the products of these factories — *all through one airlock*? How long would it take to bring a smaller ship into the airlock, close the outer door, fill the lock with air, open and unload the ship, take the goods or people into the cylinder, reload the ship, re-evacuate the airlock, re-open the outer door, and send the ship back out again? Could we do all this in an hour? It would not be easy. If we could, 24 dockings a day would be possible, including all comings and goings of people. How large a settlement could we sustain on such a basis? Hardly 10,000 people.

The life and work of every person in the settlement would be tightly linked —in a discipline quite literally military — to that docking schedule. People would go out when the list said to go out, come back when the list said to come back —and no little side trips in the air taxi to see Cousin Nell in a neighboring colony, or for picnics on passing asteroids. Life in space, for a long time to come, will be austere, difficult, harsh, rigidly disciplined, and extremely dangerous.

The space colonizers tell us that, hard and dangerous as this venture may be, we have no choice but to undertake it, since space solar power stations are the only way to supply our energy needs on earth. This is not so. At current energy prices, which by the way are expected to increase by 50 per cent in the next five years or so, solar or photovoltaic cells would have to cost about 50 cents per watt to be competitive with other energy sources. They now cost about $13 per watt; in short, about 25 times the cost of competing sources. But their cost has been dropping by about one-half each year for several years. If this rate of decline continues, solar or photovoltaic cells will be competitive with other energy sources within five years. If their cost declines at only half this rate, they will be competitive in ten years. None of this takes into account the use of concentrating collectors, one of the best (and cheapest) of which has been developed by Roy Kaplow and Robert Frank at M.I.T. Since these collectors can concentrate the sun's energy by factors of 10 or more, they may and probably will make solar energy for heat, electricity, or steam generation competitive with other sources in fewer than five years.

So the energy crisis which space-based, microwave-projecting solar generating stations are supposedly going to solve will in fact *be* solved — and at vastly less expense — long before a lunar base could be completed and operating, let alone the space generating station or space colony itself. The space colonizers are talking about a budget of $10 billion a year for their work. But anyone who puts a billion dollars on the table *today* and says, "I will buy a billion dollars worth of solar cells at 50 cents a watt" can probably get his first deliveries of cells within a year or two. We know how to make solar cells more cheaply. The problem has been that until now there has not been enough demand to encourage the needed investment in capital machinery. And for another billion, certainly another $10 billion, we could build systems to store the energy of sun

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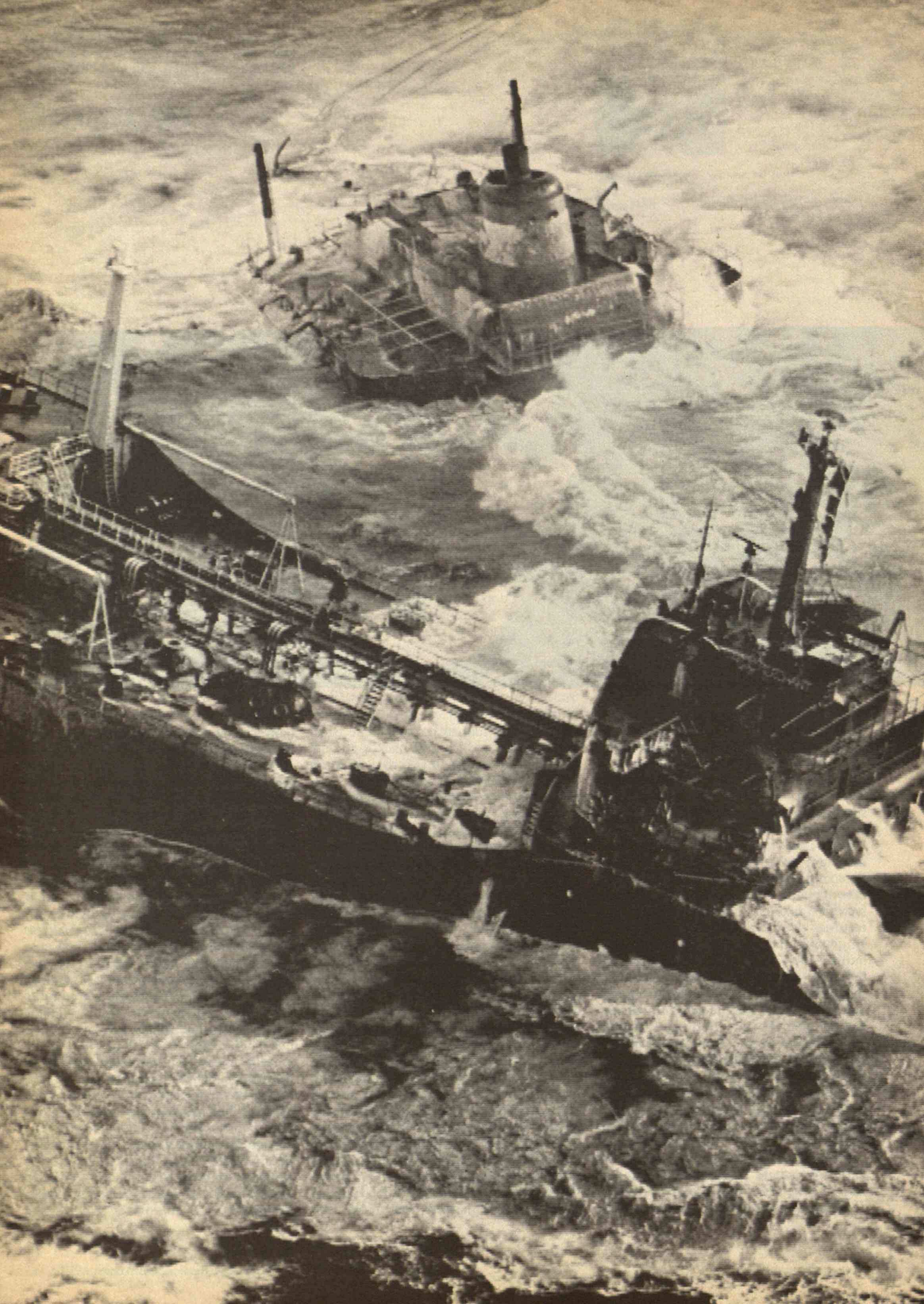


Jerome Milgram
Professor of Ocean Engineering
M.I.T.

Drawing on lessons from the loss of the Argo Merchant's cargo, the author proposes a total spill cleanup system to help protect the U.S. from oil pollution.

Being Prepared for Future Argo Merchants

The grounding and break-up of the Argo Merchant in December, 1976, and the subsequent oil spill brought to public attention just how inadequately prepared we are for dealing with offshore oil tanker accidents. This lack of preparedness applies both to cleaning up oil from the seas and to salvage of the ship and cargo before or during oil spillage.

Although each marine tanker accident is different and requires a somewhat unique response, there are a number of relatively common features. Therefore the important events of the Argo Merchant incident can tell us a great deal about what is needed to contend with such events in the future. It is the purpose of this article to describe those events and to draw from them some conclusions about means for dealing with similar events in the future.

I. Events of the Argo Merchant Incident

At approximately 6:00 a.m. on Wednesday, December 15, 1976, the Argo Merchant ran aground on Fishing Rip, a shoal about 27 miles southeast of Nantucket Island, Mass. The grounding damaged the vessel and flooding of the engine room soon began. This flooding disabled the ship's power-making machinery, and thus power-driven machinery, such as the ship's pumps, were soon inoperative. Furthermore, steam could no longer be supplied to the heating coils in the ship's tanks so that the oil cargo began slowly to cool.

A Cargo of Oil That Gets Very Viscous When Cold

The Argo Merchant carried No. 6 oil which is so viscous at low temperatures that it is difficult to pump. For example, at 10°C. the viscosity of the No. 6 oil carried by the Argo Merchant was about 35,000 centipoise. (To put this in perspective: the viscosity of water at room temperature is about 1 centipoise and that of a typical crude oil also at room temperature, is about 100 centipoise; the cold No. 6 oil has a consistency not unlike that of thin peanut butter.) Such heavy oil is usually kept warm (90° to 120°F.) during shipment so that it can be pumped off with relative ease when the ship arrives at its destination. The cooling which begins when steam is lost from the heating coils in the tanks takes place relatively slowly; generally it would take several days for the temperature of the oil in the ship to reach that of the surrounding sea.

At 7:00 a.m. on Wednesday the U.S. Coast Guard station in Woods Hole, Mass., received a MAYDAY message from the ship. During Wednesday, the Coast Guard delivered emergency water pumps to the ship, and personnel from the Coast Guard cutters Sherman and Vigilant assisted in operating them to pump water out of the flooded engine room. Of course, water was leaking in at the same time because of the damage. The damage to the ship also resulted in some of the cargo of No. 6 oil leaking into the engine room. This oil was cooled off by the cold sea water, and it was then so viscous that it fouled the pumps. The estimated sea water temperature in the engine room was about 10°C. (the sea water temperature outside was about 6°C.).

By Wednesday evening, a Coast Guard helicopter had put strike team personnel and one ADAPTS (Air Deliverable Anti-Pollution Transfer System) pumping system aboard the vessel. Three strike teams, one on each of the Atlantic, Gulf, and Pacific coasts, are maintained by the Coast Guard for dealing with oil spills and potential oil spills. An ADAPTS pumping system is designed for offloading oil from a stricken vessel; it consists of a power source, a submersible offloading pump intended to be submerged in a ship's tank, and hoses. The pump is driven by an integral hydraulic motor which operates from high-pressure hydraulic fluid delivered to it through hoses by the power source. The latter is a self-contained diesel engine, hydraulic fluid pump, and associated machinery.

An ADAPTS system is designed to offload between 1,000 and 2,000 gallons of oil (having a low to moderate viscosity) per minute.

In the case of the Argo Merchant, the ADAPTS system was not used for offloading oil but rather for pumping water with some oil out of the flooding engine room and into the sea. Because of moderately high winds and seas and the dark of night, more ADAPTS systems were not brought aboard during Wednesday evening. Indeed, even to bring the one ADAPTS system aboard the strike team personnel had to cut loose all the ship's antenna wires that ran between the midships and after houses so that a helicopter could safely operate to lower the ADAPTS components on a cable.

At this time the ship was still the responsibility of the

The break-up of the Argo Merchant on December 21, 1976. The author believes that the loss of her 7.7 million gallons of heavy oil was not inevitable, and he uses events of the Argo Merchant accident to show how existing knowledge might be used to provide technology which would deal effectively with such accidents in the future. (Photo: Wide World)

owners, who hired the Murphy Pacific Salvage Co. to carry out salvage operations; the Murphy Pacific representative was brought aboard the ship by Coast Guard helicopter on Wednesday. During Wednesday evening and Thursday, while the single ADAPTS system was pumping oily water from the engine room, the Coast Guard personnel and the representative of Murphy Pacific studied the situation to determine the best course of action.

The Crucial Question of What to Do

At this point, it is appropriate to describe some aspects of the situation in which these people found themselves. They were aboard a damaged and grounded ship with a flooding engine room and with a heel angle sufficient for the starboard side of the main deck to be nearly awash. Furthermore, the ship had taken on an abnormal trim, with the stern lower than normal and the bow higher. With the available equipment and facilities, it was impossible to determine the precise nature of the damage.

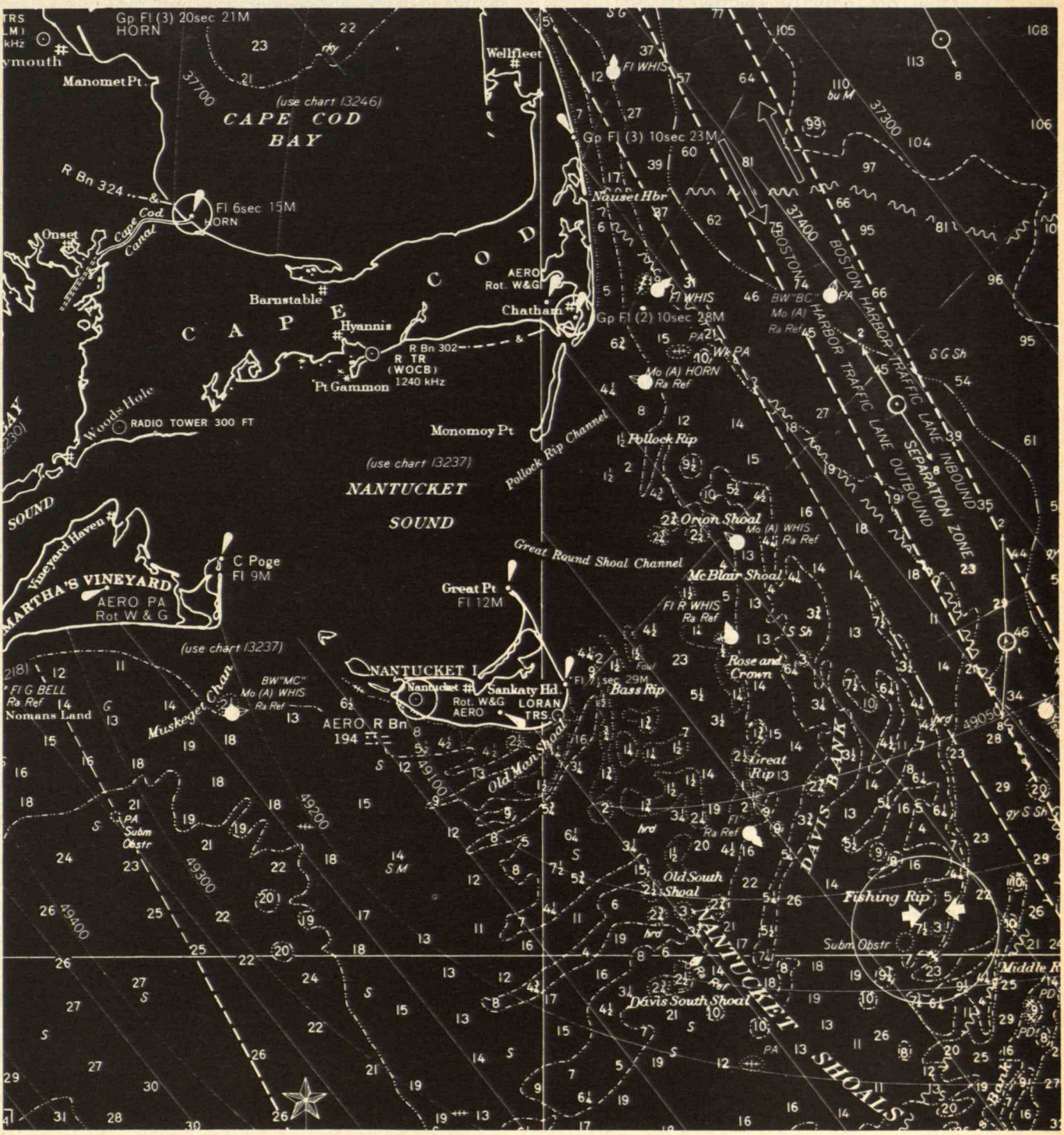
Although the basic design parameters of the ship and even curves of ship stability were available and the amount of abnormal heel and trim could be measured on board, determination of the exact nature of the flooding in various parts of a ship was impossible because the vessel was simultaneously grounded and flooded. If only one of these two situations — grounding or flooding — had existed, the basic loads on the vessel could have been determined from measurements of the heel and trim and use of the available information. This would yield knowledge about the amount and location of flooding in the case of a damaged vessel or the magnitude and location of the load on the bottom of a grounded vessel. But with simultaneous grounding and flooding, this determination could not be made. Therefore, those aboard the Argo Merchant made measurements of the height of the liquid in a number of tanks as well as could be done under the circumstances, with the intent of comparing these with later measurements to then obtain information about the amount of flooding and its distribution. The flooding information about a stricken vessel is generally needed in order to determine the best way to use whatever pumping capacity is available — in other words, to decide which compartments to pump out. In the case of the Argo Merchant, with the observed engine room flooding, it was obvious that the pump should be used to empty water out of the engine room.

During Wednesday, the Coast Guard had requested that the nearest available empty barge be brought to the scene to receive offloaded oil. A major problem in the use of a barge for offloading a stricken tanker in the presence of large waves is that of providing fendering between the barge and vessel. The owners of the Argo Merchant did not have large fenders available, and three of the four adequate fenders possessed by the Coast Guard were hundreds of miles away. The Coast Guard made arrangements for two fenders and two more ADAPTS pumping systems to be transported to the Coast Guard Air Station on Cape Cod, where the pumping system arrived later on Wednesday and the fenders on Thursday.

By Thursday morning, the 15-knot winds and six-to-eight-foot seas that had existed in the vicinity of the Argo Merchant during Wednesday had diminished; and those aboard the vessel reported that the initial engine room flooding, which had reached a height of 22 feet, had been reduced to 15 feet by the single ADAPTS pump. By 8:00 a.m. on Thursday the two additional ADAPTS systems along with additional strike team members were aboard the U.S. Coast Guard buoy tender Bittersweet in Woods Hole, Mass., and the Bittersweet shortly thereafter left Woods Hole for the Argo Merchant.

Early Thursday afternoon, the personnel aboard the Argo Merchant found that the water in the engine room was again rising. They knew that additional ADAPTS pumping systems would soon be aboard, and there must have been some question in their minds as to how they should be used. Should the additional pumps be used in the engine room to try to lower the water level there? On the other hand, some of the tanks of the vessel (the vessel contained 30 cargo tanks) appeared to be flooding. Should the additional ADAPTS pumps be used to pump water out of some of the apparently flooding starboard tanks (since the vessel was heeled to starboard) in order to help right the vessel and possibly float her free of the shoal? If any tank had a large hole in its bottom, no good could be accomplished by pumping because the tank would flood to the waterline level no matter how much was pumped out of it. If the hole in a flooding tank were so small that water entered through the hole more slowly than fluid was removed by pumping, then the water level could be lowered and additional buoyancy thereby provided. If it could be ascertained that there were some undamaged cargo tanks, additional buoyancy could be provided to the vessel by pumping oil from such tanks. But nobody then on board the Argo Merchant could assume responsibility for pumping oil overboard even if undamaged tanks could have been located, so nobody would make a decision to do this.

The grounding of the Argo Merchant occurred on Fishing Rip, a shoal about 27 miles southeast of Nantucket Island, Mass., at 6:00 a.m. on December 15, 1976. The nearest major U.S. port was Providence, some 90 miles distant, and Coast Guard facilities were available at Woods Hole, less than 50 miles from the scene. The major fishing grounds of Georges Bank lie to the north of Fishing Rip, which is marked by two arrows at the lower right. Water depths are shown in fathoms — one fathom being six feet. (Chart: N.O.A.A. 13006)



Here, another diversion is in order. Under circumstances that existed aboard the Argo Merchant at this time, and which have existed or will exist on other ships under similar conditions, there is no decision an individual can take which can do him very much good. On the other hand, there are many possible decisions which can do one much personal harm. Thus, in situations like this, decision-making is inhibited at the very time when effective response actually requires firm and decisive decision-making. The technical matters are difficult enough; somehow, the social and institutional pressures must be eliminated in order to encourage decision-makers to take the best possible action.

The Situation Deteriorates: Buckling and Strange Sounds

The Bittersweet arrived alongside the Argo Merchant at about 3:00 p.m. on Thursday. The two ADAPTS systems and additional strike team personnel were offloaded, and the Bittersweet left the scene. Prior to this time, the responsibility for the Argo Merchant was that of the owners, exercised by the representative of Murphy Pacific Salvage Co. He had decided to use one of the additional ADAPTS systems for pumping water out of one of the starboard cargo tanks which was supposed to have contained no oil when the ship left Venezuela, but which appeared to be flooding. By this time, the heel of the vessel had increased, the sinkage towards the stern was larger, and the sea state was increasing with waves beginning to break onto the deck. This resulted in considerable time being required to set up the ADAPTS system and associated hoses. The reader should try to appreciate how difficult it is for men to handle large, heavy six-inch diameter hoses covered with slippery oil on a tilted deck covered with slippery oil with waves and spray coming down upon them. It was dark by the time the pumping system had been set up on Thursday. When pumping began, it was not water which came out of the tank, but oil.

This further increased the uncertainty of the situation. Could it have been that the tank was not empty of oil when the ship began the voyage even though the crew reported that it had contained no oil? Could a bulkhead between that tank and another tank have been damaged in the grounding, resulting in a leak so that oil from an adjacent tank poured into a previously empty tank? Could the condition of the ship before the voyage have been so bad that there was leakage between one tank and another so that a tank initially containing no oil eventually filled with oil? These questions and others must have been going through people's minds, and no answers to them were available.

During Thursday afternoon, the Coast Guard assumed command of the salvage operation under authority of the 1974 Federal Intervention on the High Seas Act. No doubt this was done because the owners of the vessel had not accomplished any positive steps toward salvage. All pumping up until that time had been done by Coast Guard personnel with Coast Guard equipment. The owners had made no plans for rapid delivery of barges, fenders, or pumps for offloading cargo, nor had they made any arrangements for cleaning up oil that had spilled or might later spill. The strike team aboard the vessel was informed of the Coast Guard intervention by radio. Murphy Pacific Co. remained on the salvage assignment, working now under a Coast Guard contract.

At about 7:00 p.m. Thursday evening, a tug, the Sheila Moran, arrived at the scene, apparently at the request of the Murphy Pacific Co. Since there was nothing she could do to help at that time, she stood by on scene.

During Thursday evening the wind, now from the northwest, increased as did the size of the waves and the number of waves breaking onto the main deck of the vessel, whose low (starboard) side was toward the waves. Some buckling of the main deck on the aft portion of the ship had been observed, and leaking of oil from a cargo tank into the engine room around bolts or rivets in a bulkhead could be seen. Strange sounds were emanating from the ship structure in the region of this bulkhead as a result of the loads caused by the seas and the bottom against the grounded vessel. Only the one ADAPTS pump was being used, taking water out of the engine room. No one aboard knew how long the ship would last. No one could know. Even though the Coast Guard had assumed command of the salvage operation, both the Coast Guard personnel and the representative of Murphy Pacific were trying to figure out the best thing to do. It was then clear that very little could be done immediately.

Many of the ship's tanks were inspected by opening cover plates, and a considerable number of the tanks exhibited much agitation and sloshing of the surface of the oil. This suggested that the bottom of the ship might be torn open to damage many tanks, in which case pumping oil out of them and overboard would most likely not have aided in ship salvage. Water was rising in the engine room and it seemed doubtful that pumping more water from the engine room with additional ADAPTS pumps would stem the tide. Furthermore, it was deemed by everyone aboard to be extremely dangerous to work in the vicinity of the engine room; the behavior of the deck and the bulkhead between the aftermost pump room which was full of oil and the engine room, together with the sounds the structure was making, indicated that the vessel might break there at any time.

As a result, a decision was reached to take all personnel off the vessel, and this was accomplished by Coast Guard helicopters late Thursday evening. When the lights from the helicopters illuminated the scene, it became clear that oil leakage into the sea at a substantial rate had begun. It was uncertain as to how much of this oil was coming out of deck openings and how much was coming out of the damaged bottom at this time.

At about 4:30 Friday morning, 47 hours after the grounding, the 140,000-barrel barge Nepco 140, towed by the tug Marjorie D. McAllister, finally arrived. However, seas were four to six feet high with worse weather predicted, and the Coast Guard chose to concentrate on other tasks rather than deliver fenders to the ship and bring the barge alongside the Argo Merchant. There was substantial oil pollution at this time; the author estimates the pollution rate to have been approximately 40,000 gallons per hour.

A Salvage Plan: Stabilize, Heat and Pump

Ever since the grounding of the Argo Merchant, the heading of the vessel had been changing from time to time. It is not certain how much of this heading change was due to wave forces and how much was due to forces of the currents. The currents at the location of the grounding are somewhat unique in the sense that they are rotary, not reciprocating. Whereas in most locations tidal currents go in one direction and then switch to go in the opposite direction, on Nantucket Shoals the current direction rotates through all headings.

Date (December)	Sea Condition	Ship Condition	Potential Barrier Effectiveness*
15	Rough, 10-foot waves	Only small leak	Ineffective
16	Calm, one-foot waves	Larger oil leak	Totally effective — negligible oil loss
17	Medium, 4-foot waves	Substantial oil leak	Effective — oil loss of five gallons per minute
18	Rough, 6-9-foot waves	Substantial oil leak	Ineffective
19	Calm, very small waves	Substantial oil leak	Totally effective
20	Calm, small waves	Two million gallons spilled	Totally effective
21	Rough, 7-9-foot waves	Ship broke up, releasing much oil	Ineffective
22	Rough, 10-foot waves	Bow section broke, releasing much oil	Ineffective
23	Calm, 3-foot swells		Totally effective
24	Medium, 4-foot waves		Effective — oil loss of five gallons per minute
25	Medium, 5-foot waves		Effective
26	Medium, 3-foot waves		Effective
27	Rough, 8-9-foot waves		Ineffective
28	Medium		Effective
29	Rough, 4-foot waves plus 6-foot swells		Partially effective — oil loss of approximately 40 gallons per minute
30	Rough, 7-foot waves plus 14-foot swells		Ineffective
31	Medium, 2-foot waves plus 6-foot swells		Effective

* *Totally effective* — negligible oil loss under or over barrier; *effective* — small oil loss, on the order of five gallons per minute, *partially effective* — oil loss on the order of 40 gallons per minute; *ineffective* — if there were in fact a pool of oil inside the barrier, loss from it would be on the order of 150 gallons per minute.

Sea conditions and the author's estimate of how effective U.S. Coast Guard high-seas barriers could have been in the case of the Argo Merchant accident. Lack of an adequate number of tow vessels with appropriate capabilities would have reduced the effectiveness of the barriers.

The salvage plans generated by Murphy Pacific began with stopping the heading changes of the ship by putting out two bow anchors. Then a group of heavy moorings, each with a mooring buoy, were to be located around the ship to which barges could be tied. A work vessel was to be brought alongside the Argo Merchant, with fendering to be provided by the two large Coast Guard fenders which had arrived at Cape Cod. This work vessel was to contain a steam heater which could be used to pump steam through a portable coil in one Argo Merchant tank after the other to reheat the oil to a temperature at which it could be pumped.

Conditions on Friday, December 17, were somewhat rough, and work was limited to inspection of the ship since all of the planned equipment for salvage was not yet available. Saturday, December 18, was even rougher. Wind strength increased to over 40 knots and seas were nine to twelve feet high with almost every wave breaking on the shoals. Although the amount of heeling of the vessel seemed to change as the tide changed, the stern of the vessel was definitely sinking lower and lower.

By Sunday morning, December 19, the wind and seas had abated and conditions were nearly calm. In a combination of effort by Coast Guard strike team personnel and the tug Sheila Moran and her crew, one of the bow anchors of the Argo Merchant was put out. In the calmer conditions, the rate of oil leakage appeared to be somewhat less than before.

Wind and sea conditions were also moderate on Monday, December 20, but during the night conditions worsened and by the morning of Tuesday, December 21, strong northwest winds and large seas were again present. At 8:30 a.m. the Argo Merchant split in two and a great deal of oil escaped. By Wednesday morning, the wind strength had reached 45 knots and the seas were about 12 feet high. At about 9:00 a.m. on Wednesday, a section of the bow which had been afloat broke in two and most of the remaining oil escaped.

From the standpoint of pollution damage, we were all very lucky in the case of the Argo Merchant accident. Personnel of the Coast Guard had realized the pollution threat from the beginning and had brought their high-seas oil booms and skimmers to the air station at Cape Cod. But this equipment was never used. Although at the time of the grounding the wind was from the southwest, all strong winds were from the north or the northwest during all of the time that oil escaped from the vessel. This resulted in the oil being driven away from the shore and generally to the south of Georges Bank. Only for one short period following the spilling of the oil did the wind blow toward land, and some oil came to within 15 miles of Nantucket Island. But then the wind direction again changed to the northwest and the oil was blown out to sea.

We will not always be so lucky. Statistics about wind direction indicate that such good fortune can be expected most of the time during the winter along the Nantucket shore. However, most of the time does not mean all of the time. In addition, winds toward shore are more prevalent there in the summer. There are, of course, many locations in the United States where the situation is reversed and the most frequent winds blow toward the shore.

If the Argo Merchant oil had been blown onto shore, we would presently be dealing with a coastal disaster of major proportions. Any region which has a large quantity of oil blown onto its shores will have such disaster.

II. Preparedness for Response to Stricken Vessels

The preceding description of events is intended to provide a framework for considering optimum planning, equipment, personnel and training, for diminishing the magnitude of such disasters as that of the Argo Merchant in the future.

There have been no significant advances in the technology of the salvage of vessels grounded offshore during the past 30 years. Such an advance is now within our reach if funding and the attention of competent engineers is brought to bear on the problem. The subject of regulations to decrease the likelihood of tanker accidents is not a subject of this article; it is being given much attention elsewhere. However, the subject of regulations to make tankers easier to salvage if they run aground is a subject considered here.

Stronger Ships With Double Bottoms

The Argo Merchant lasted just longer than six days after it grounded; during part of this time, the weather was quite rough. In 1970, the tanker Arrow which ran aground in Chedabucto Bay, Nova Scotia, lasted four days before breaking up. The Torrey Canyon lasted about one week.

The fact that tankers generally seem to last several days after grounding indicates that the breakup is not caused by any particular instantaneous load exceeding that which the ship can initially withstand; rather the process is one of fatigue, the result of reciprocating loads causing deterioration of either the macrostructure (frames, joints, etc.), the microstructure (metallurgical characteristics of the steel), or both over a period of several days.

A feature of fatigue failure is that for specified loading conditions, a small increase in strength will often greatly extend the number of cycles a structure can withstand before ultimate failure. Since grounded tankers generally seem to last several days before breaking up, it seems quite possible that a relatively small increase in structural strength could result in grounded tankers generally lasting several weeks. Studies to confirm this hypothesis are within the capabilities of ship structures experts, and such studies should certainly take place. If the expected lifetime of a grounded vessel could be materially increased, many salvage operations could take place which are not possible when the expected lifetime is only a few days. If studies indicated that a modest increase in structural strength would markedly increase the expected lifetime of a grounded vessel, regulations upgrading the structural standards for tankers entering U.S. waters would be appropriate.

Much has been said and written about the advisability of requiring tankers to have double bottoms to minimize the threat of leakage due to grounding. But there is an important structural reason for believing that the use of double bottoms could be quite helpful in lengthening the expected lifetimes of grounded vessels. When a vessel runs aground, its bottom is usually damaged. Today's large ships are designed with the beam substantially exceeding the depth; this is done to increase cargo holding capacity without increasing ship draft, the draft being the factor which limits areas the ship can serve because of limited water depth. The ability of structures which are relatively wide and shallow to withstand sidewise bending is far greater than their ability to withstand vertical bending, when the maximum loads are carried on the ship's bottom and deck. If the bottom is damaged upon grounding, one of the primary structural members (the bottom) for withstanding vertical bending is at least less efficient and sometimes completely ineffective. On the

other hand, if a vessel had a double bottom and the outer bottom were ruptured, the inner bottom could still contribute significant vertical bending restraint.

Adding Buoyancy as a Salvage Strategy

It is useful to understand the enormous amount of buoyancy which can be required to refloat a grounded vessel. The Argo Merchant was a relatively small tanker by today's standards. It could carry approximately 27,000 tons of oil. The weight of the ship itself, exclusive of cargo, was about 18,000 tons. Suppose, for example, that the damage to the ship was such that to refloat it would require an external buoyancy equal to half of the weight of the ship itself, not including cargo. In the case of a ship the size of the Argo Merchant this would be 9,000 tons.

I was once asked why the ship could not have been lifted off the shoal with helicopters. The Sikorsky Skycrane — the helicopter having the largest lifting capacity of which I know — can lift about 12 tons; thus 750 such helicopters working simultaneously would be required to lift half the weight of the steel of the Argo Merchant. Obviously that would not be a practical solution. However, there are some practical solutions; the most practical of which is an arrangement whereby a stricken ship could refloat itself. It was impossible to do this with the Argo Merchant with the equipment that was on board. However it is feasible to require that ships be equipped so that all deck openings could be sealed in a time of one hour or less. Suppose it had been possible to completely seal all deck openings on the Argo Merchant. If this could have been done, and if air were then pumped into the tanks above the cargo while as much cargo as was displaced by the air was pumped into the sea or a waiting barge, the 9,000 tons of buoyancy would have been achieved when the level of liquid in the ship's tanks had been depressed only six feet. This would have been effective whether the bottom were ruptured or not; it requires only that deck openings be sealed. Fittings to accept air lines could be required on the top of each tank, and emergency salvage equipment could include compressors and hoses to supply the air. Retrofitting existing vessels to meet these requirements could be entirely practical.

Consider what this would have involved, had it been possible, in the case of the Argo Merchant. First of all, the deck opening seals and the deck structure itself would have had to withstand an internal pressure of approximately three pounds per square inch above atmospheric pressure (a practical requirement). Approximately one-third of the ship's cargo or an equal weight of ballast water would have had to be discharged to allow space for the air. Under the conditions of the Argo Merchant grounding, the only practical place to discharge this cargo (which would amount to about 2 million gallons) would have been overboard. As it was, 7 million gallons were spilled.

Limited Liability for Decision-makers

Authorizing the discharge of 2 million gallons of oil into the sea is a responsibility which an individual simply cannot take under existing political conditions. In the case of the Argo Merchant, for example, even though the leaking oil was moving offshore and apparently without damage to Georges Bank, all actions of the Coast Guard were mercilessly and unjustifiably attacked by the Lieutenant Governor and the Secretary for Environmental Affairs of the Commonwealth of Massachusetts. It is not hard to imagine the nature of these attacks if Coast Guard officers had been in a position to save the ship and most of the cargo by electing to deliberately discharge 2 million gallons of oil into the sea.

A workable procedure for exercising human responsibility must be prearranged in a special way if optimum response to stricken tankers is to occur in the future. For each vulnerable region of the United States coastline, one most appropriate individual should be designated in advance as the one who will have the ultimate responsibility for making decisions regarding stricken vessels in the area.

These individuals must be assured in advance that they will not be held accountable for any unpleasant results resulting from well-founded decisions. For example, suppose — as in the case of an Argo Merchant with sealable deck openings — that a northwest wind would blow discharged oil safely offshore and that a northwest wind was forecast for a reasonable future period. Further suppose that the deck openings could be sealed and air pumped into the tanks above the oil. The best immediate decision under these circumstances could very well be to pump 2 million gallons of oil overboard in order to refloat the ship and make possible towing her to safety. Now suppose that one day after 2 million gallons of oil were pumped overboard the wind unexpectedly shifted and the oil came ashore. Under no circumstances should the person responsible for the offshore decisions or the weather forecaster whose predictions were not fulfilled be held accountable for this occurrence, and this fact should be a law.

How to Assess Invisible Damage

Every oil tanker accident is different. If a grounded vessel were equipped to close deck openings and withstand internal air pressure, salvage by the means described above might be appropriate in some instances. An example of such an instance is the Argo Merchant accident. Since the oil was No. 6 and since cargo heating had been lost, the oil could be moved with relative ease only for a few days. One day after the accident the wind began coming from the northwest, and the weather forecast was for increasing northwesterly winds for several days. If the tanker had been equipped so that deck openings could be closed, some cargo could have been discharged and the resulting spaces above the cargo filled with air; this action would have been an appropriate salvage strategy for the environmental conditions that existed for many days starting on Thursday morning.

In other instances such a course of action might not be appropriate; this would include, for example, those when forecast winds would be certain to blow discharged oil ashore. How might a grounded tanker be salvaged under such circumstances?

The first requirement would be knowledge about the extent and nature of damage. If this were known and if some time for salvage operations could be anticipated, then the most appropriate steps to restore bouyancy could be planned and taken.

If the tanker had deck openings which could be sealed and deck structures which could withstand internal pressure, much useful information could be learned about the condition of the ship structure by measuring the pressure in each tank resulting from air being pumped into it. If there were no openings between the tank and the outside environment, the pressure would not subsequently slowly drop; if there were a path from the tank to the outside environment, the pressure would slowly diminish.

Were there broken bulkheads between otherwise intact tanks in the Argo Merchant? We will never know for sure. But if the deck openings could have been sealed and if we had been prepared with the proper instruments, we could have found out by measuring the size of the air space above the cargo in any tank, and then measuring the relationship between the amount of air pumped into a tank and the resulting rise in pressure. We are a long way from being able to do this now. Not only are tankers built without the provision for complete sealing of all deck openings above tanks; we lack equipment for rapidly making the measurements as described. It is useless to try to pump liquid cargo from a tank having a large hole to the sea. Water will enter as fast as it is pumped out.

The point of these measurements is to identify intact tanks which can be used to obtain buoyancy by offloading their cargo and replacing it with air. If intact tanks are not found, some flotation can be provided by removing liquid cargo from a tank having only a small hole to the sea.

If a situation were not appropriate for discharge of the cargo into the sea, the most rapid technique would be to bring barges alongside. This requires prompt availability of barges, and it requires lightweight rapidly deployable fendering systems to use between barges and the stricken vessel. Such systems do not now exist, but they are clearly within the reach of present technology and should now be developed.

In the case of the Argo Merchant, it took about 47 hours for a barge to reach the scene of the incident, which was only 26 miles from land and 90 miles from a large commercial port — in this case Providence. Such response is too slow by at least a factor of five. What is required for faster response? State or federal governments must have contracts with barge operators all around the coastline of the nation to provide prearranged barge capacity on very short notice. Contracts for barge capacity on a "best effort" basis are not sufficient, and "surprise tests" called by the contracting agency should be used to make barge operators frequently demonstrate their ability to meet their contracts.

Those who carry out the salvage operations would necessarily have to be highly trained. Presumably they would be groups something like the existing U.S. Coast Guard strike teams and quite logically could be the strike teams themselves. How could adequate training be assured? Again, "surprise tests" — exercises which would really test how well the people could do their job — would have to be carried out frequently. For example, at random and unannounced intervals a derelict ship filled with a non-hazardous dye could be towed up on a shoal and the strike forces called. Their performance could be measured by the amount of dye that escaped into the sea before the salvage operation was completed.

One well-known technique of marine salvage has never been used on a scale which is appropriate for salvaging as large a ship as a modern tanker. This is the supplying of external buoyancy to the stricken vessel by special flotation tanks which are flooded, attached to the vessel, and then pumped out. It seems appropriate to study the possibility of developing a technology which could apply this technique on a large scale. Many changes from today's smaller scale operations would be needed. For example, it is possible that the only practical way to attach a suitable flotation chamber to a stricken vessel with sufficient strength would be by welding. Can the technology to do this in the presence of substantial seas be developed? I do not know; but we could find out with a relatively straightforward feasibility study.

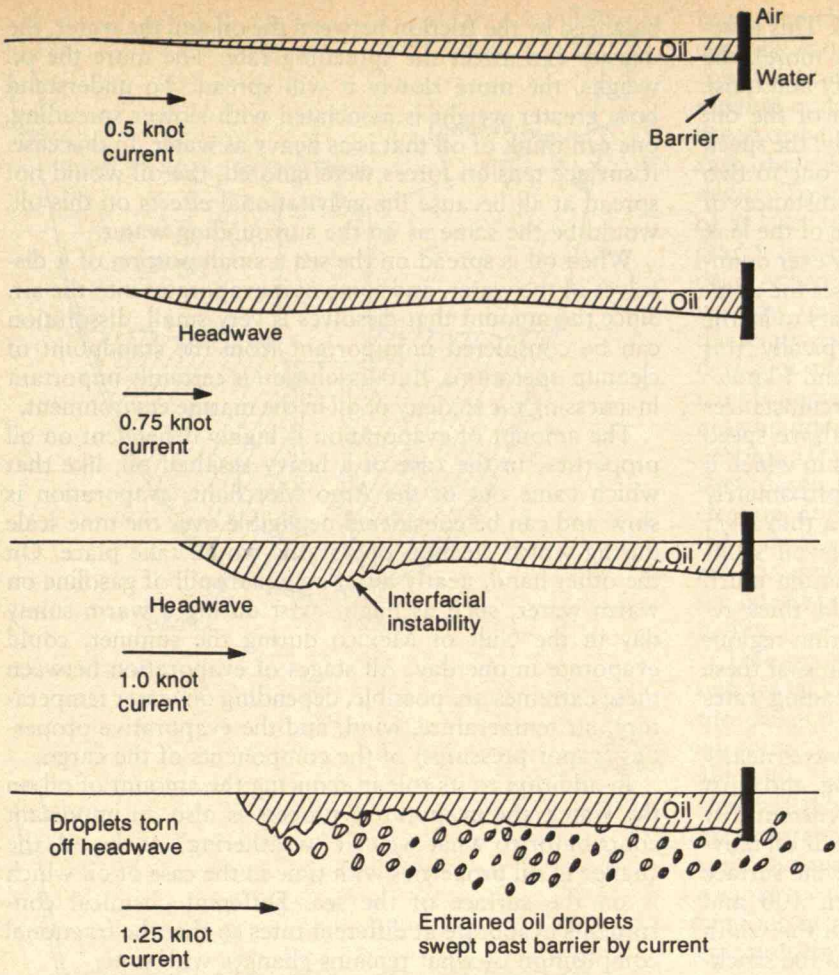
Whenever a large tanker is grounded, many people ask about the possibility of burning the oil. Usually this cannot be done. However, it seems entirely feasible to design and build special burners which could be placed aboard stricken tankers for the purpose of burning the cargo. The questions which must be answered first are: How much air pollution would this cause; and, How rapidly could the burning be done? Engineering studies to answer these questions are in order.

III. Preparedness for Cleaning Up Spilled Oil Offshore

Although details of the salvage of ships and their cargoes are complicated and difficult, the fundamental techniques of a salvage operation are generally easily understood, and they are relatively well known. This is not true of the cleanup of oil spilled on the surface of the sea, which is a fundamentally more complicated subject.

First consider the basic geometry of an oil spill on the sea. Two factors strongly influence the distribution of the oil in the vicinity of a spill: how the oil is spilled, and how it is spread by action of water, wind, and tides. Only rarely do these combine to form a continuous oil pool of relatively constant thickness on the surface of the sea.

Each accident has a somewhat different scenario for the spilling of oil. In some accidents the oil is released relatively slowly, and in some accidents it is released relatively quickly. In the case of tanker groundings, the usual



Consider slowing down oil by a simple oil boom, a floating fence (black bar in chart). If the boom is towed slowly, with a speed relative to the water and oil of 0.5 knots, the oil is held against the boom as shown at the top; in the absence of ocean waves, the oil pool, as viewed in cross section, is relatively smooth. At a higher relative speed of about 0.75 knots, the oil pool forms a headwave near its leading edge, as shown in the second drawing. At a still higher relative speed of about one knot, the size of this headwave is substantially increased and there is instability in its lee; and at an even higher speed (about 1.25 knots), oil droplets are torn off the headwave by the water stream and may be carried below and past the boom or collection device. This particular effect has nothing to do with the details of the device; it results only from the fact that some of the oil is slowed down.

scenario is for a slower leak at the beginning of the process, a large release when the ship breaks up, and then a continuing slow release of oil as the broken components of the ship continue to leak the oil still aboard. It is important to point out the meaning of the word "relatively" in this context. For the Argo Merchant, the best estimate by the author of the leak rate prior to breakup, but after substantial leaking had begun, is 40,000 gallons per hour. This estimate was based on direct observation of the average slick thickness, slick width, and current speed.

The case of the Argo Merchant demonstrates how the details of the accident can affect the geometry of the oil on the sea. As mentioned before, the tidal current at the location of this wreck rotates through all compass headings, the cycle being made twice each day. Although the ship changed its heading to some extent while it was grounded, this heading change was relatively small; so at different times of each day, the ship encountered currents from nearly every possible direction with respect to its own. When the current was coming from nearly forward or aft, the oil slick near the ship was relatively narrow —perhaps 150 to 250 feet wide. However, when the current was nearly athwartship, the width of the oil slick in the vicinity of the ship was between 600 and 1,100 feet.

The Behavior of Oil When Spilled on the Sea

The effects of such details of oil release on the geometry of the oil slicks are well understood and can be predicted with enough precision to determine their implications for the logistics of cleaning up the oil. This is not the case with the spreading of the oil once it is in the sea. Although some theories for the spreading of oil have been published in the literature of hydrodynamics and of oil spill effects, we are now quite certain that these theories are not applicable to spilled oil on the sea. This is probably because they do not take into account the complex effects of surface tension in the oil-air interface and the interfacial tension between the oil and water. Generally, the result of these tensions is a spreading force on the oil; but the response of the oil to this force is extremely complicated, and for several reasons. First of all, most cargoes of oil are not made up of a single substance but rather are a mixture of different chemicals; crude oil is an extreme example; it is made up of a vast number of different chemical substances. The different constituents respond differently to the surface tension forces. Some components spread very rapidly and effectively contaminate a large surface area. This contamination can retard the spread of the remaining oil to a surprising degree. Even with a single substance, initial rapid spreading of a very thin layer can retard the spread of much of the remaining oil. These effects contribute to the fact that most oil slicks are found to have interspersed regions of thin and thick layers of oil. The thick layers appear to float around within the thin layers and to spread very slowly into them.

We can give some measures of how fast oil is expected to spread. In the event of a sudden release of a large quantity of oil, the initial stages of spreading are accu-

rately predicted by existing published theories. This is because when the oil layer is thick (one foot or more), the spreading is dominated by the forces of gravity and those required to accelerate the horizontal motion of the oil, and these effects are well understood. Typically, the speed of the edge of the slick in such a situation is one to two knots. However, the oil slick rapidly thins; at distances of more than a few hundred feet from the source of the leak these effects no longer dominate. Nor are they ever dominant during a relatively slow leak. In these cases the dominant mechanism of spreading generally appears to be the effects of surface tension and gravity. Typically this spreading takes place at speeds between 0.25 and 1 knot.

It is important to realize that under some circumstances the surface contamination spreading at the above speed can contain very little oil. There are examples in which it is only one or two molecules in thickness (approximately 10^{-6} inch), and under some conditions such a thin layer may be invisible. On the other hand, visible oil slicks composed of both thick and thin regions contain much more oil than those described above, with the thick regions being 0.05 to 0.4 inches thick and the thin regions being 0.001 to 0.05 inches thick. The spreading of these usually takes place more slowly, with spreading rates being on the order of 0.1 knot.

A water current induced by tide, wind, or waves nearly always exists at the scene of a tanker grounding, and most of the spilled oil moves in the direction of this current. For a relatively slow leak, then, we expect a track of oil moving away from the ship at about the speed of the surface current and with a width typically between 100 and 1,500 feet. This general picture prevails, with the width slowly increasing, at increasing distances from the stricken ship. The increase in width occurs in two stages; the most rapidly spreading parts, whose slick contains extremely little oil, move out first, followed by the slower spreading of what most people call the thin region of the oil. These thin regions are often fed by spreading from the edges of the thick regions which float within the slick.

We would expect oil from a sudden, large discharge to spread somewhat more rapidly than oil from a relatively slow discharge until the average thickness of the oil diminished to approximately 0.5 inch. Typically, more rapid spreading could be expected to continue until the general diameter of this region was between 1,000 and 4,000 feet, depending on the volume of oil spilled.

How Different Oils Behave on the Sea

How do the properties of the oil itself affect its distribution in the sea? We have already discussed the importance of surface tension for oil spreading. Some oils have such high oil-air and oil-water tensions that surface tension actually tends to contract the size of the slick. In this case, the very thin layer one or two molecules in thickness is absent, and spreading depends on the extent to which gravitational forces causing spreading forces can overcome the retarding forces related to surface tension and viscosity.

Another property which affects the gross spreading of the oil is its density. The density does not affect the relatively rapid spreading which occurs immediately after a sudden release of oil, since it affects the gravitational spreading forces and the force required to accelerate the oil in exactly the same counteracting ways. However, during the later stages of spreading, when spreading forces due to surface tension and gravity are basically counterbalanced by the friction between the oil and the water, the density can affect the spreading rate. The more the oil weighs, the more slowly it will spread. To understand how greater weight is associated with slower spreading, one can think of oil that is as heavy as water. In this case, if surface tension forces were ignored, the oil would not spread at all because the gravitational effects on this oil would be the same as on the surrounding water.

When oil is spread on the sea a small portion of it dissolves in the water, and some of it evaporates into the air. Since the amount that dissolves is very small, dissolution can be considered unimportant from the standpoint of cleanup operations. But dissolution is certainly important in assessing the toxicity of oil in the marine environment.

The amount of evaporation is highly dependent on oil properties. In the case of a heavy residual oil, like that which came out of the Argo Merchant, evaporation is slow and can be considered negligible over the time scale during which cleanup operations would take place. On the other hand, nearly all of an equal spill of gasoline on warm water, such as might exist during a warm sunny day in the Gulf of Mexico during the summer, could evaporate in one day. All stages of evaporation between these extremes are possible, depending on water temperature, air temperature, wind, and the evaporative properties (vapor pressures) of the components of the cargo.

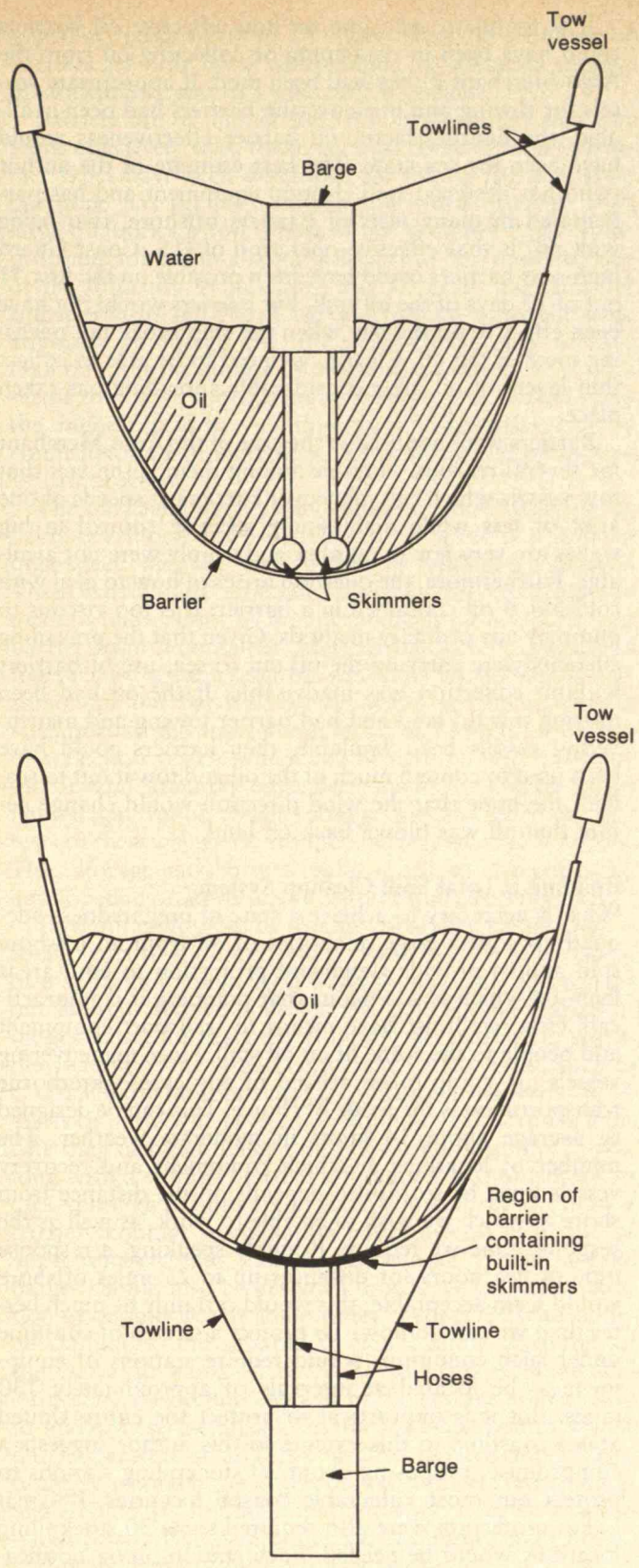
In addition to its role in reducing the amount of oil on the water, the evaporative process is also an important contributor to what we call "weathering" of the oil, the change in oil properties with time in the case of oil which is on the surface of the sea. Different chemical constituents evaporate at different rates so that the fractional composition of what remains changes with time.

When ocean waves break on an oil-covered surface, oil droplets are dispersed into the water beneath the waves. The density, viscosity, and oil-water interfacial tension have a considerable bearing on this dispersion of droplets into the water column, affecting how many droplets are formed, how deeply they will go, and how quickly they will rise to rejoin the slick. Typically, we expect a substantial number of droplets to be dispersed between the surface and a depth equal to about twice the wave height. Lesser quantities of droplets are dispersed at greater depth. This effect has a bearing on spill cleanup operations, since surface equipment cannot encounter oil which is dispersed to great depths.

As the reader can see, the immediate fate of spilled oil is influenced by the properties of the oil itself, the temperature and movement of the air in the vicinity of the spill, and sea and current conditions. Clearly there are many advantages to be gained by rapid cleanup response, as this minimizes the extent to which the oil spreads and is carried by waves and currents. The more the oil has spread and the greater the areas which it has affected, the more difficult is the cleanup task. Since spreading is so much affected by the properties of the oil, the optimum logistical plans for rapidly cleaning up any spill depend on knowing the oil properties as well as weather and sea conditions. The possibility of having information on its cargo available for every tanker entering U.S. waters should be studied at once.

The Limits of Barriers and Skimmers

There are a number of hydrodynamic limitations on oil spill cleanup operations which must be considered. Any device which collects oil must move at some speed with



These diagrams show two possible arrangements of barrier and skimmers for collecting spilled oil offshore. In the drawing at the top, skimmers operate efficiently in a thick pool of collected oil at the apex of the barrier, and the collected oil is pumped forward to a storage barge. In the arrangement at the bottom, skimmers to collect oil are built into the barrier and the storage barge is towed behind. The critical problem in both arrangements is to retain control while towing the barrier and skimmers at speeds no greater than one knot; entrained oil droplets escape under the barrier if it is moved at higher speed relative to the oil slick.

respect to the oil and water. If the oil and water are essentially stationary, the device must move in order to encounter a continuing stream of oil; if the oil and water are moving in a current, the device can either move at some speed or be stationary in order to encounter oil. In either case, there is a relative speed between the liquids and the device. To some extent, any device slows down the speed of at least some of the encountered oil. Considerable research has been done on the hydrodynamic effects that occur when oil is slowed down in a relative current, and we now understand that there is a natural limitation in the relative speed of any effective containment or cleanup device of about one knot. Exceeding this limit will result in entrainment of oil in the water, with this entrained oil moving under and past the device.

Some cleanup devices have now been developed that slow down both water and oil to an extent that allows cleanup at relative speeds up to two knots. However, these devices are limited to low collection rates, so they are not appropriate for large spills on the high seas. Thus, the one-knot limit for high-seas cleanup of large spills remains.

This one-knot limit affects oil-cleanup operations in two ways. One problem is that of properly manipulating the cleanup devices. Only rarely do wind and current combine so that cleanup devices can be operated efficiently when anchored; this is possible only when a substantial amount of oil is carried to the device anchored in a current of less than one knot. Usually effective oil spill cleanup requires the towing and maneuvering of cleanup devices. But such towing and maneuvering must be done at a relative speed of one knot or less to avoid entrainment of oil in the water column. This towing task can be accomplished only by vessels which can maintain accurate steering control in the presence of substantial waves at this low speed. Most existing vessels have good control at higher speeds, but only very few can maintain sufficient steering control to properly tow and maneuver cleanup equipment at speeds of one knot or less.

The second problem is related to the oil encounter rate for the cleanup device. The first phases of the Argo Merchant incident provide a good example of typical leak rates in an oil tanker grounding. The estimated leak rate of 40,000 gallons per hour corresponds to 667 gallons per minute. The slick containing substantial oil in the vicinity of the ship was observed to be between 150 and 1,100 feet wide, depending mainly on the current direction. A typical current velocity was about 1.5 knots in the general area (although the velocity was often higher over localized areas). This current, along with the aforementioned leak rates and slick widths, corresponds to an average slick thickness between 0.0070 and 0.046 inches (0.18 to 1.18 millimeters) a typical figure. Assuming the mean of the two thicknesses given, which is 0.026 inches (0.67 millimeters), the encounter rate of a skimming vessel moving at a relative speed of one knot with a skimming width of 75 feet would be 124 gallons per minute. This is only about 19 per cent of the postulated leakage rate, and it represents a very small collection rate for a large skimming device. In the case where the current was crosswise to the ship, leading to a slick about 1,100 feet wide, the oil encounter rate (which would be the maximum possible collection rate) of a 75-foot-wide skimming vessel would be only 34 gallons per minute.

The only practical device for collecting oil under these conditions is a high-seas oil-pollution-control barrier,

made of flexible material and strong enough to be used in lengths of up to thousands of feet (*diagrams, page 25*). Such a towed barrier could in fact have encountered all of the oil (667 gallons per minute) estimated in the example cited above. In this example, the current speed was 1.5 knots, whereas it has been stated that the relative speed of collection equipment and current cannot exceed one knot. The solution is to use two collection systems, each operated at a relative speed of one knot, each in effect backing away from the wreck at a speed of one-half knot. As the distance from one cleanup system to the wreck increased, the second system would start near the wreck and slowly back away. The first system, after collecting all the oil between the two systems, would return to the wreck and begin again. The problem of determining the number of cleanup systems and the logistics of their use is an exercise in pre-planned oil spill control whose solution could be worked out for each possible situation.

The Problems of Waves

Another hydrodynamic limitation on oil spill cleanup is that imposed by wave motion. Most cleanup systems can collect large volumes of oil and small volumes of water only if they follow relatively well the motion of the waves on the surface of the sea. Such wave-following action is nearly impossible at the bow of a collection vessel; for example, in six-foot seas there are many circumstances where the instantaneous wetted waterline at the bow of a collection vessel would move up and down by a full six feet. Under these circumstances, efficient collection of oil would be essentially impossible. Some work has been done on articulated oil inlet devices to be used at the bow of a vessel to reduce, in part, the relative motion between the fluid and the vessel. This leads to a partial solution for very small waves (three feet or less), but another limitation may make refinement of this technique useless. This is the fact that when a vessel has a large relative motion with respect to the sea, the motion of the vessel itself generates a type of wave which drives away from the vessel much of the oil it was attempting to collect.

The oil containment and cleanup devices which have the very best wave-following ability can be divided into two categories. The first include specially designed high-seas barriers which can have skimmers built into them. These barriers are designed so that much of the sealoads are carried in lines external to the barrier fences, thereby leaving the fences relatively free to respond to the motion of water and oil. The second category comprises systems using within the oil pool captured by a towed barrier several skimming devices which are relatively small and light and therefore follow the surface of the sea with much greater accuracy than fewer large, cumbersome devices.

Yet despite these developments, the use of barrier-based skimming systems is limited by the roughness of the seas. No barrier systems yet designed can work effectively in large, breaking waves. Indeed the maximum breaking wave height in which barriers now available can contain and collect oil is about eight feet. Much larger non-breaking waves (swell) can be tolerated. Larger barriers that could effectively work in larger seas could certainly be designed and constructed, but their size and weight would probably make them impractical. In addition, in larger breaking waves much of the oil is expected to be temporarily dispersed well below the surface. When conditions become less rough, much of the dispersed oil returns to the surface.

It is useful to speculate on how effective oil barriers could have been in containing or collecting oil from the Argo Merchant if they had been used. If appropriate vessels for towing and maneuvering barriers had been available, the limiting factor on barrier effectiveness would have been the sea state. The best estimate of the author (who has designed spill cleanup equipment and has participated in many tests of barriers offshore, two being with oil) is that effective operation of U.S. Coast Guard high-seas barriers could have been possible on the first 11 out of 17 days of the oil spill. But barriers would not have been effective on the day when the ship broke up, releasing most of the oil. Clearly, we need to be able to collect thin layers of oil after considerable spreading has taken place.

Barriers were not used in the case of the Argo Merchant for several reasons. Notable among them is the fact that tow vessels which can maneuver barriers at speeds of one knot or less while maintaining steering control in big waves are very few in number and simply were not available. Furthermore, the question arises of how to deal with cold No. 6 oil contained in a barrier; it is too viscous to pump by any ordinary methods. Given that the prevailing currents were carrying the oil out to sea, use of barriers without collection was inadvisable. If the oil had been moving toward land and had barrier towing and maneuvering vessels been available, then barriers could have been used to contain much of the oil and tow it out to sea, with the hope that the wind direction would change before that oil was blown back on land.

Building a Total Spill Cleanup System

What is necessary to achieve a state of preparedness adequate to collect large quantities of oil from an offshore spill and to provide significant protection to land areas from oil which is so viscous that pumping it is impractical? First, we must have means to transport equipment and people to the scene of an oil spill. Since maneuvering vessels are going to be needed in any case, waterborne transportation is the mode of choice. This can be designed to average about 14 knots in moderate weather. The number of locations at which equipment and recovery vessels must be stockpiled depends on the distance from shore at which we wish to be able to work, as well as the response time we require. Roughly speaking, a response time of five hours for distances up to 25 miles offshore would seem acceptable; this would certainly be much better than we can do now. To protect a stretch of coastline under such conditions would require stations of equipment to be located at intervals of approximately 130 miles. But it is impractical to protect the entire United States coastline to this extent; so this author suggests a compromise, proposing about 20 stockpiling stations to protect our most vulnerable coastal locations. If Great Lakes protection were also required some 30 stockpiling locations would be needed. Each station, upon notification of a spill, should have or be able shortly to obtain barriers with built-in or separate skimmers, storage vessels, tow vessels, and trained personnel.

Barriers capable of holding oil on the high seas in breaking waves up to eight feet high and in very large non-breaking waves exist, although in inadequate numbers. Some of these barriers are available in lengths of about 600 feet, packaged in containers whose loaded weight is about 15,000 pounds. The Coast Guard has developed special sleds on which such packages can be

towed at speeds of up to 20 knots. Thus the problems of barriers are only those of obtaining an adequate supply, of stockpiling, and of routine maintenance.

Barriers are of limited use without skimmers that can work effectively with them. At least three different skimmer types have been developed for use on the high seas, but none has yet been thoroughly tested offshore with large quantities of oil. None of the skimmer types is appropriate for use in a large spill of cold No. 6 oil because of the difficulty of pumping this material, but most oil transported is not No. 6 oil and initially it would seem advisable to forego the ability to collect this difficult material. It is the author's opinion that offshore tests with oil of the most appropriate skimmer types should have the highest priority, so that their capabilities can be confirmed and procurement — or further development — can proceed.

The packaged barriers and skimmers now available or being developed can be carried to the scene of a spill on high-speed planing sleds towed by high-speed vessels. These barriers are especially designed for rapid deployment (it takes about 20 minutes to deploy a 600-foot long barrier from a container, and barriers can be connected together for greater length); so it may fairly be said that skimmers and barriers can be available very quickly if stockpiled in the appropriate location. But this is not true of collection vessels which can be used to store collected oil. Several attempts have been made to develop large, lightweight rubber bags suitable for this purpose, but tests of these bags have resulted in their structural failure. Thus storage capability remains a crucial element to be developed in order to achieve a total spill cleanup system.

Two different types of storage capability are needed — small, lightweight barges to be towed quickly to the scene of a spill, and commercial barges which can be brought out later to receive collected oil. The special collection barges would be designed as lightly as possible; in effect, they would be the largest containers which vessels such as Coast Guard 82-foot cutters could tow at speeds of 14 knots or more when empty. Preliminary calculations indicate that such lightweight barges would be about 75-feet long with a storage capacity of about 100,000 gallons of oil — enough to hold about three hours of collection by a barrier-skimmer combination collecting oil at a rate of approximately 600 gallons per minute. These storage barges should also be designed to achieve gravity separation of oil and water; some water is collected with oil by all skimmers, and separation would allow discharge of the water so more oil could be collected. Commercial barges are the second element of the storage system, and to make these facilities available we must contract with barge operators on all U.S. coastlines to have empty barge capacity available on a few hours' notice. The requirement could be for an initial capacity in each location within a relatively short time (for example, eight hours) and more capacity over a longer period.

Maneuvering vessels are a third requirement item for a total spill cleanup system. As has been explained previously, effective cleanup will usually require towing barrier-skimmer combinations at speeds of one knot or less. Vessels capable of towing at such speeds while maintaining steerage control in waves of substantial size are now few in number. Power requirements are very small; a few hundred horsepower is more than sufficient. The crucial issue is the ability to tow continuously at slow speed in sizeable waves with steering control adequate to properly handle barrier-skimmer combinations. It is quite within our capabilities to retrofit a large number of existing vessels so that they have this capability, and it is also entirely feasible to add low-speed towing capability to the same vessels which are planned for high-speed response with equipment and personnel. Both these retrofit programs should be undertaken at once, since several barrier-skimmer-barge combinations — and therefore numerous tow vessels — are likely to be needed at the scene of an offshore oil spill.

Finally, consider the matter of trained personnel. Controlling an oil spill offshore is a difficult task which can be done only by personnel who are thoroughly trained in the job. Because personnel can be transported quickly by air, such groups need not be stationed at every location where equipment is stockpiled. Indeed, we need only to expand somewhat the present U.S. Coast Guard strike team concept and assure that thorough and regular training takes place.

A total spill cleanup system would include barriers, skimmers, storage vessels, tow vessels, and trained personnel, as described. Each item is critical; hence the importance of the stockpiling proposal. If any one of these elements is absent, even if all of the remaining items are provided, essentially no oil cleanup can take place.

Note

This article is adapted with only minor changes from Report 77-10 of the M.I.T. Sea Grant Program. It describes results of research done with support from the Office of Sea Grant in the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and from M.I.T. The following related reports are available from the Sea Grant Information Center, Room 5-331, M.I.T., Cambridge, Mass., 02139, at the prices indicated:

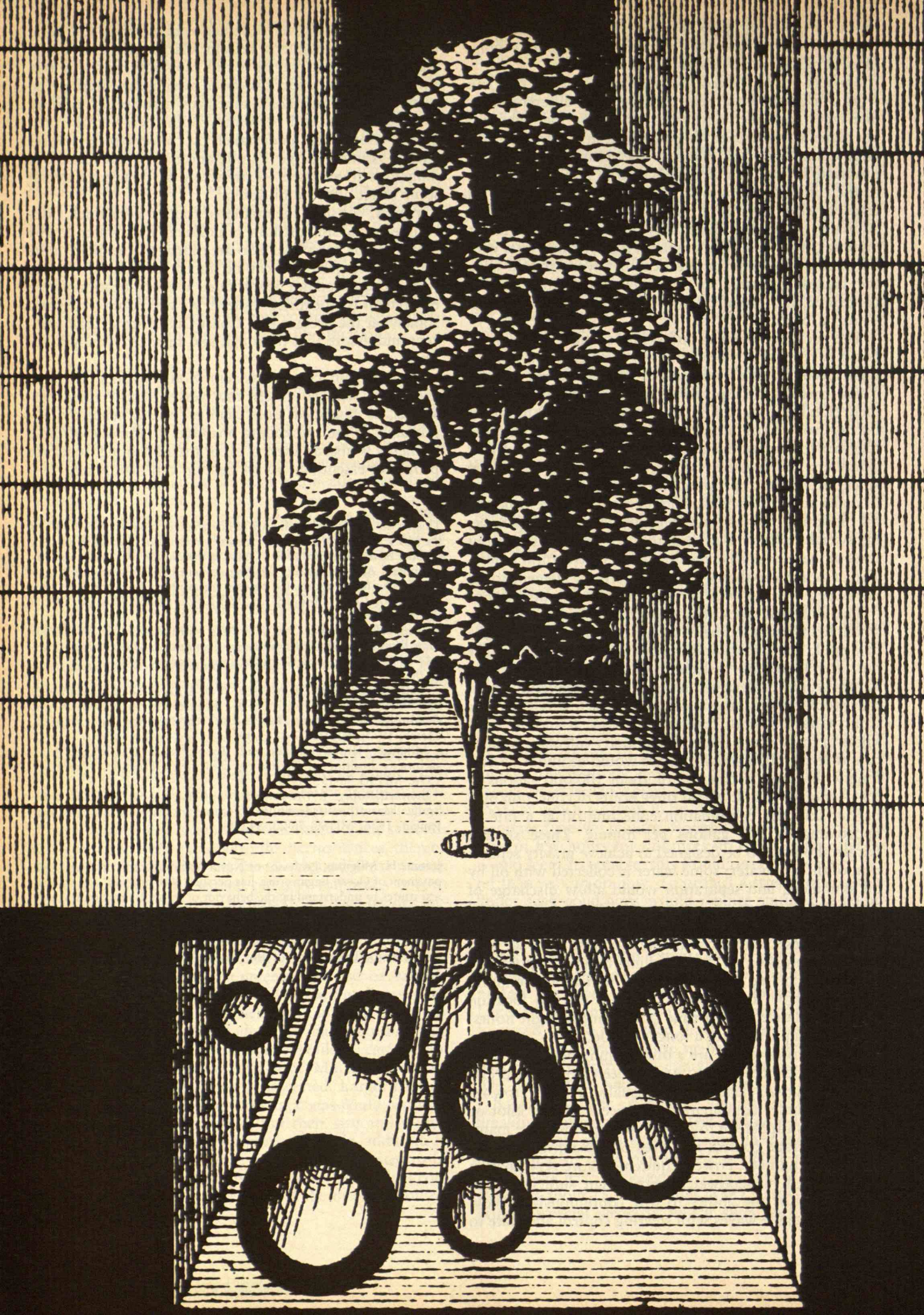
Campbell, Brad; Ed Kern; and Dean Horn. *Impact of Oil Spillage from World War II Tanker Sinkings.* Cambridge: Massachusetts Institute of Technology Sea Grant Program, March, 1977; MITSG 77-4, $2.00.

Stolzenbach, Keith; Ole Madsen, et al. *A Review and Evaluation of Basic Techniques for Predicting the Behavior of Surface Oil Slicks.* Cambridge: Massachusetts Institute of Technology Sea Grant Program, March, 1977; MITSG 77-8, $5.00.

Milgram, Jerome. *Waves and Wave Forces.* Cambridge: Massachusetts Institute of Technology Sea Grant Program, November, 1976; MITSG 76-19, $1.00.

Stewart, Robert J. *The Interaction of Waves and Oil Spills.* Cambridge: Massachusetts Institute of Technology Sea Grant Program, September, 1976; MITSG 76-22, $4.00.

Jerome H. Milgram, Professor of Naval Architecture in the M.I.T. Department of Ocean Engineering, has pursued both practical and theoretical routes to understanding the behavior of oil spills and ocean waves. He was on board the Argo Merchant with Dr. Edward Kern, of the M.I.T. Lincoln Laboratory, and he has conducted important studies of waves and currents in special facilities of his design in the Marine Hydrodynamics Laboratory of the Ocean Engineering Department at M.I.T.



Ruth S. Foster
Landscape Consultant,
Former Assistant Tree Warden
City of Boston

Roots: Caring for City Trees

Forestry conjures visions of the woodsman surveying the emerald seclusion of Evangeline's forest. No more.

Lumber production, once the main concern of sylviculture, has taken a back seat. More and more specialists have come to appreciate the psychological necessity of trees in the city, and now they're good business. From 1974 to 1976, Boston spent $700,000 on trees. In Massachusetts, about $10 million is spent on urban trees each year. Nationally, the budget approaches $500 million.

Urban forestry is a new discipline based on a synthesis of many familiar subspecialities: biology, forestry, architecture, city planning, park management, sanitary engineering. It represents a new perception of an old problem. With the establishment of the national Metropolitan Tree Improvement Alliance in 1975, urban forestry has come into its own. According to Frank Santamour, head of tree research at the National Arboretum in Washington, D.C., "M.E.T.R.I.A. represents the first joint effort of forestry, research, arboretum, nursery and park experts, working together to provide and use better trees on the streets." Twenty-eight forestry schools now offer special courses in the field.

Urban forestry does not mean no-growth. Environmentalists are often accused of wanting us all to freeze in the dark, while the giants of industry want us to choke to death in overheated skyscrapers. Urban forestry belongs to neither camp. Instead, it attempts to make cities more habitable by creating growing environments, filled with plants most likely to thrive.

Urban forestry is not mysterious. And it is no more expensive than creating barren, wind-swept plazas where nothing will grow. It requires an understanding of biomass production in planning cities and breeding trees. It involves basic street layout, sewer drainage, engineering and architectural design, and studies of soil, wind, sunlight, and temperature. Finally, it depends upon plants that are genetically suited to the growing pockets that have been made for them.

Urban forestry also means accepting that in some places, trees will be too costly. When trees cannot survive without great expense or constant replacement, they ought to be planted elsewhere. For example, in Boston's red-light "Combat Zone" — site of the original Liberty Tree in 1775 — five trees were planted on a little brick-paved island. Because of complicated underground wiring, the trees had to be placed in concrete tubs that must be removed by cranes when the wires need repair. Total cost of installation: $200,000 — probably more than the tiny oasis is worth.

The Tree Factory

Trees are an energy system. And they provide cities with practical as well as aesthetic benefits.

The life processes of trees influence both climate and air quality. A mature tree has been estimated to cool a volume of air equal to five 10,000-watt air conditioners, by evaporation of water from the leaves. It is estimated that if Richmond, Va., replaced its trees with air conditioners, its energy bill would be $800,000 a year.

Convection air currents produce cooling breezes under trees on even the hottest days: the temperature drops 10 to 20 degrees underneath. Carbon dioxide is absorbed and oxygen given off, improving the ambient air quality in cities. The leaves absorb pollutants and particulate ash. They also absorb solar energy in summer that would otherwise be radiated from pavements and buildings as heat. In winter, being leafless, they conveniently allow solar energy to penetrate and warm the surrounding masonry.

City Ecosystems

The city ecosystem is made of the same parts as the forest where trees normally grow. It has its own particular soil, prevailing wind, compass orientation, hillside or mountaintop site, watershed configuration, and plant communities. In the forest these aspects are solely nature's creation. In the city they are manmade, so that who built what, when, and what they left underground may be more to the point than the traditional questions foresters ask.

By and large, cities are warmer than their surroundings. In downtown Boston, for example, the climate is as warm as farms in New Jersey — warmer than Lexington and Concord just ten miles away. When the forsythia blooms in Boston, it will not bloom for ten days beneath the statue of the Lexington Minuteman. The reason? Cities experience a "heat island" effect, absorbing the energy used to heat buildings, run autos, and power equipment. The concrete absorbs additional heat from sunlight and holds it. At night, radiation heat loss is minimized by heat held by buildings and pavements. The air temperature stays higher. Smoke, smog, and too much carbon dioxide further inhibit outward energy flow.

Because cities are warmer, they are congenial to tender plants. But plants that need a cold winter — such as certain birches — may suffer. In the forest, clustered trees shade one another's trunks. But in cities, trees are bathed in direct and reflected solar energy each day of the year. Cells that should remain dormant and frozen are con-

Illustration: Joe Landry

Fact: The average survival of trees in the city is ten years.
Fact: The engineer is the most common cause of urban tree death.

tinually thawing and freezing. Frost cracks and sunscald are common, particularly on young trees whose bark has not had time to thicken. Winter sun and wind are both desiccating and disruptive of dormancy. The result is many dead buds and twigs when spring comes. The damage is not usually fatal, but biomass production is seriously compromised.

In summer, the alternate effect takes place. There is slower cooling at night. The sun heats the plants by day; the concrete sidewalks and buildings absorb heat and keep the nights warm. More water is necessary for healthy growth. It is rarely available.

Consequently, city trees often adopt the growth habit of the desert. Smaller new leaves and shorter new growth conserve moisture. The bark and stems thicken. The tree begins to be stunted. Energy is not devoted to new vigorous growth, but instead to seed production to insure the survival of the species in the stressed environment.

While some spots have too much sun, some have too little. Photosynthesis does not occur below 50 footcandles. Plants on the due north side of tall buildings may get only two hours of sun on the day of the summer solstice, less the rest of the year — not enough to sustain healthy growth. These plants are candidates for continual replacement. Artificial light can help. For example, areas under the sodium vapor lights used for traffic control can be planted, and the energy used for two purposes at once. Further, some plants grow better in heavy shade than others. They must be specified at planting time.

Advance planning is the key to healthy city plants. On the drawing board it is easy to create wind baffles, provide water runoff through planting areas, and plan for winter shade and summer sun protection. The best sites on the east and south can be saved for planting. Trees suited to desert tolerance may be used or developed.

The Stress Response

The stress response is the cumulative effect of the urban environment on trees. The trees grow less, mature too early, and die too soon. In their weakened condition, they are easily killed by any fungus or insect that happens by. While the stress response is familiar to foresters, its effect in the urban setting is just being investigated.

In the forest, insects and fungi usually attack weak or diseased trees, thus clearing room for healthy new growth. Insect, fungus, and plant co-exist, each serving to preserve themselves, one another, and thus the forest. Clear-winged moths, for instance, are secondary attackers of ash trees in the forest; healthy trees are rarely attacked. However, all urban trees fall prey to the moths, which are genetically pre-adapted to go for stressed trees.

While the coup de grâce for most urban trees is usually fungus disease, the real culprits are the conditions causing stress syndrome. Some of the most common stresses are described in some detail below. Bioengineering can relieve many of them; a Machiavelli is needed to solve the others.

Water stress: It is no accident that trees grow fastest in tropical rain forests, since water is the major constraint upon weight-volume production. In cities, soil compaction is endemic and renders the soil unable to absorb rain. Sidewalk trees must survive on whatever they can take in through their tree pits. But the average city pit is 3 ft. by 2 ft. or 3 ft. by 3 ft., so the amount of water directly absorbed is inadequate.

Simple remedies are available. Sidewalks can be graded to drain into tree pits, instead of into the streets. Gutters can have scupper holes which course water to the trees *(see diagram, p. 32)*. But scupper holes don't work if salt is used heavily; in that case, tree pits should be curbed above the runoff and salt resistant species planted.

Simple engineering can provide inexpensive irrigation. No use is made now of gutter or roof runoff water; it is piped directly into storm sewers. If it were directed through the tree pits, trees would be watered and the total load on the storm sewers lessened. Shalimar and the other famous terraced gardens of the Kashmir use water from the Himalayan mountains to course down from one level onto the next, and so on. The same water is used again and again for irrigation at each level. We pipe roof water out and irrigate with faucet water which has been purified — at great expense — for drinking.

In parks and open spaces, water stress is not so acute as in sidewalk pits and planters. However, even there an underground water table makes the difference between good and stressed tree growth. Surface rainfall is rarely adequate to cover summer evapotranspiration rates, and so prevent an early cessation of the spring growth spurt, and a too early fall dormancy. Both are triggered by less and less water, which causes the tree to misread the seasons. Reflected heat augments the problem. The city trees grow less and suffer leaf scorch early. The loss of leaf tissue compromises food manufacture. The growth cycle changes. Vigor declines.

Obviously, additional loss of leaf surface from pollution or disease worsens the syndrome, so that it becomes a self-generating cycle. A healthy tree could put out a second flush of leaves and make adequate food for the next

year. Without underground water resources during summer, the city tree will not have the reserves to cope.

Too much water can also be a problem. Tree roots require gas exchange to metabolize properly. When the air spaces in the soil are constantly filled with water, the roots drown and finally rot. Some trees — elm, red maple, gum, and willow — will survive intermittent flooding and airless roots better than others. Unfortunately, most are unsuitable for city streets. Willows clog sewers and water lines. Elms are prone to Dutch elm disease. Red maples are salt sensitive. Sweet gum alone is successful, although it may have difficulty maintaining vigorous growth in compacted soil.

If all city water is piped to sewers, what is the source of flooding? Some pits are dug in impervious soil. (For this reason, cherry trees planted in a new residential development on Welfare Island in New York City did poorly. It turned out their tree pits drained into impervious rock.) And planters may have inadequate drainage. Both these conditions may be relieved by layering stone and charcoal under the soil; drainage holes are better yet.

Most commonly, flooding results from poorly designed irrigation systems. Most systems are designed for golf courses which must be kept lush and green. Water percolates through the grass roots in the top 8 in. of soil and runs back into lakes and streams. In the city, while water also percolates, it may not run off.

In addition, irrigation must complement usual rainfall patterns. For example, on Commonwealth Avenue in Boston, 100 ft. tall elm trees were lovingly treated to a costly irrigation system — about $100,000 per block. An enormous amount of root damage was done during construction. When the system became functional, it was set on automatic timers that watered the mall each night, but no one calculated the total amount of water delivered. After a few years, many huge trees began to fail: their leaves were small; their new growth weak; the roots were rotting. A simple calculation showed that 8 in. of water monthly was being deposited during June, July, and August for a total of 24 in. Yet, the average rainfall for that period was only 9.87 in. and the average evapotranspiration only 16.56 in. So irrigation was needed to fill a total deficit of less than 7 in., and the irrigation time had to be quartered. To further complicate matters on Commonwealth Avenue, the mall is only a few feet above sea level on a filled tidal bay of silt and clay. The large trees were accustomed after 65 years to live on the 9.87 in. of rainfall. Suddenly the soil was always drenched. It never drained. The trees languished.

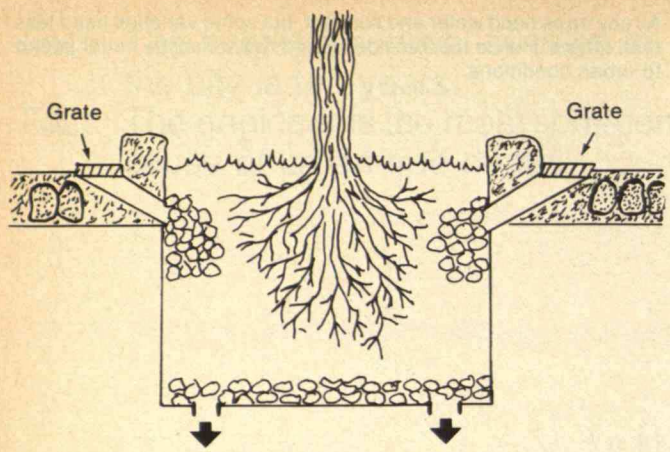
All city trees need water and sunlight, but some varieties need less than others. Hence the trees described below may be better suited to urban conditions.

Drought-resistant trees

Box Elder (Acer negundo)	60 ft.	Weak-wooded; poor street tree; grows easily; drops too many seedlings which become weeds
Tree of Heaven (Ailanthus altissima)	60 ft.	Grows anywhere; not beautiful; use female only
Silk Tree (Albizzia julibrissin rosea)	35 ft.	Attractive, low-spreading branches; feathery leaves; pink summer flowers
Modesto Ash (Fraxinus velutina glabra)	35 ft.	Satisfactory; withstands alkaline soil
Honey Locust (Gleditsia triacanthos)	80 ft.	Excellent street tree; small leaves; easy to move; "Moraine" most resistant to webworm
Golden Rain Tree (Koelreuteria paniculata)	30 ft.	Good street tree; flowers in summer; weak-wooded; hard to transplant
Chinaberry (Melia azedarach)	45 ft.	Tough; grows quickly; drops too many seedlings
Pagoda Tree (Sophora japonica)	75 ft.	Excellent street tree if pruned to high crown; summer flowers

Shade-resistant trees

Vine Maple (Acercircinatum)	25 ft.	Shrubby, small trees; not good for street but will grow better than most
Striped maple (A. pensylvanicum)	35 ft.	
Mountain maple (A. spicatum)	25 ft.	
Shadblow (Amelanchier canadensis)	40 ft.	Useful if pruned to a single trunk
Dogwood (Cornus florida)	35 ft.	Not a street tree; withstands city conditions if watered
Pin Cherry (Prunus pensylvanica)	35 ft.	Short-lived; tough; red fruit
Carolina Hemlock (Tsuga caroliniana)	75 ft.	One of the only hemlocks that can grow in the city; needs water, wind protection



An easy source of water for city trees is to equip gutters with scupper holes, as above; the result is a giant, self-watering pot. Water flows from the gutter through a grate, and filters through rocks to the tree's roots. The water then drains through rocks at the base of the tree pit.

At Boston's Faneuil Hall, another air transport and irrigation system problem developed. The marketplace is also only a few feet above the original harbor salt flats; the area was part of the original settlement of Boston. It was filled early in the city's history and has since been paved. When new tree pits were first dug, they filled up with water during high tide. The new irrigation flooded the near trees and didn't reach the far ones. When the engineering was corrected the trees became ill — not from flooding, but from hydrogen sulfide gas escaping from the disturbed tidal muck below. The trunks had to be slit from top to bottom and the planting pit enlarged to let the gas escape.

Wind stress: In nature, most trees shun windswept slopes, particularly the deciduous trees commonly planted on city streets. But in the city, each avenue creates a minor wind tunnel. The taller the buildings, the greater the canyon effect.

Winter winds are several compass points different from summer ones. Tall buildings either funnel or baffle them. One of the old colonial maps of Boston for tourists shows a "Cold Street" on old North Bay, in the direction of the prevailing winter winds. New City Hall, near the old bay site, funnels the wind right through the plaza, as well as the more westerly summer wind. Trees planted in the path of the winds are desiccated both winter and summer. Some survive, some languish, none thrive. Another row of trees grows behind a low building, which blocks the winds. Flowers are planted around the bases and are watered during summer. Those trees thrive. The original plan should have provided for trees only in protected spots.

Construction: Planning suitable locations for trees is important, but protecting those that have managed to establish a foothold is necessary as well. Insensitive engineering and lack of concern by contractors kill more trees than anything else. Where building specifications say, "protection of existing trees," they usually mean "try not to back the bulldozer into them."

Protection of the existing urban forest begins in the Public Works Department. Tree roots are constantly disturbed by roads, sidewalks, utility lines, bus stops, traffic signals, parking lots, parking meters, sewers, drainage, curbs, and so on ad infinitum. Few consider that destruction of more than one third of the roots can be fatal. Top pruning (to balance root loss) and fertilizing is usually ignored in construction specifications. Grades are raised and lowered at random over roots. To raise the soil over living tree roots by more than 3 to 6 in. will probably smother them. The standard specifications, which usually call for 6 in. of loam and then sod, are just too much.

New trees' roots are often left exposed for weeks while new sidewalks are being put in. Old ones are chopped to fit into neat, standard pits. Decline disease, the tree's response to this kind of stress, sets in shortly. The larger the tree, the longer it can live on its stored reserves, but eventually decline becomes apparent.

Permanent changes in air and water patterns compound the damage done during construction itself to the roots of established trees. Compaction during construction is endemic. If trucks aren't parked under the tree, bulldozers are. The preferred spot for storing sand, concrete, and pipes seems to be over the root system. Or it is the preferred spot for lunch. After a few months of lunch, the soil is compacted to concrete-like hardness that defies passage of air or water.

Compaction: In cities tree roots are in the cubic yard of loam in a tree pit, or in open ground, under the drip line (the farthest reach of the branches). The condition of the soil medium in which the roots grow determines their vigor. A good friable loam that absorbs water and has air spaces for proper gaseous respiration is required. In the city, soil is subject to continual compaction by the pounding of a thousand feet. Compression of vehicular wheels completes the universal squashing. Roots in compacted soil are especially subject to fungus attack, the prime agent of decline disease.

The treatment for compacted soil — whether caused by machines, feet, sporting events, or just nature lovers forever passing through — is aeration. The soil surface is broken open or scarified. Sand may be dug in or plugs of soil removed by machine. On tree pits, a mulch of wood chips or crushed stone absorbs some of the pressure while allowing air and water to percolate down.

Pollution: When people observe a sick city tree, they most often attribute the cause to air pollution. In fact, pollution is usually not the major cause of sickly trees in the city, except in areas that have high contaminant concentrations or very sensitive species. Given good growing conditions, most trees will do reasonably well. However, pollutants do take their toll in growth rate and longevity *(see table, p. 33).*

Pollutants may be airborne gases, particulate ash, or chemicals in water. The worst offender is salt. It increases osmotic pressure in the soil and desiccates the roots. At lower concentrations, it causes the breathing stomata on the leaves not to close and conserve moisture. In summer, the plants continue to transpire in the heat of day. Too soon, the leaves brown at the edges, eventually dry up, and fall. These symptoms mimic severe drought damage. As might be expected, trees that survive near the sea are most adapted to salt spray, and most salt tolerant in the city. Sugar maples were a favorite street tree in residential areas. With increasing urbanization, they are in trouble.

They can be seen with their fall coloring, bright red, in the middle of summer.

Where road safety is a first priority, additional water is helpful to combat salt damage. Flushing with water in early spring will leach out some of the salt. From July on, when signs of damage appear, extra water will slow the typical drought response.

Gas pollutants and particulate ash have various effects. The damage is typically manifest as white spots on the leaves, the result of a loss of chlorophyll cells. But the symptoms are different for each gas and each type of tree. Sensitivity varies not only between species, but between different trees of the same specie. In cities, most airborne gases come from auto emissions. Oxides of nitrogen, sulphur, and ozone cause the worst problems. Since there isn't much foresters can do to diminish the gases, the next best alternative is to keep the trees healthy, so they can overcome the resulting tissue damage. Sensitive evergreens, which do not replace their chlorophyll-bearing tissue as frequently as deciduous trees, are hardest hit.

Particulate ash (soot) causes damage by clogging the breathing pores, and blocking sunlight from the leaf surface. Again evergreens suffer more. That's why there are so few large ones in cities. Hosing the foliage with water several times a year helps.

The importance of the stress syndrome interaction is nowhere more evident than in pollution tolerance. Stressed trees suffer more from the loss of food-producing tissue. As they become weaker, they become more stressed. The result of this vicious cycle is the ten-year average survival rate for city trees.

Breeding Super-trees

As the hazards to city trees become better understood, plant geneticists are able to breed new trees that will have greater tolerance of city stresses *(see table, p. 34)*. Some trees such as callery pear seem to absorb certain air pollutants without harm, and even to thrive under adverse conditions. Japanese trees like gingko, sophora, and katsura perform better than many of our native trees. Perhaps no specific antagonistic fungi have developed here yet to harm them.

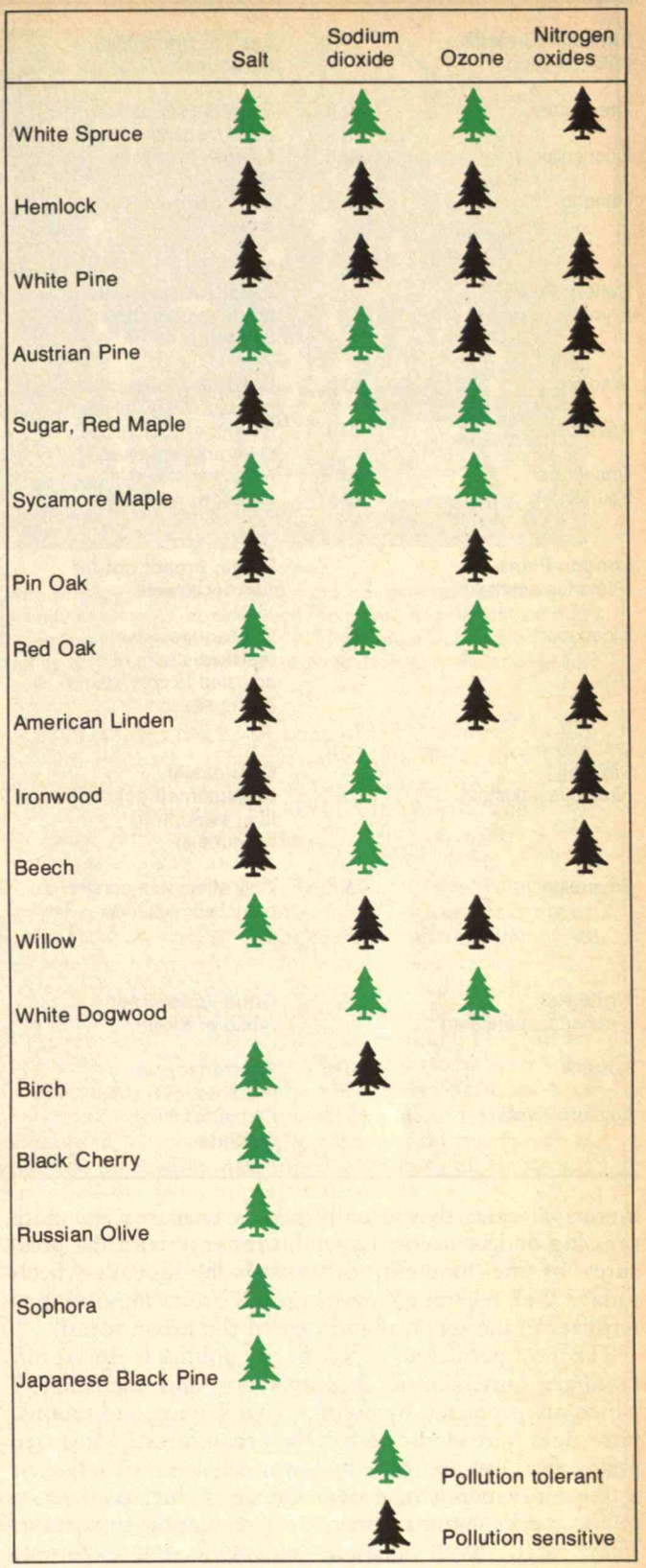
In Tennessee, white pines near coal burning plants were doing badly. (Most pine seed comes from a few breeding sources in the country.) The forestry station collected seed from local white pines that seemed healthy. Planted in a nursery near the power station, some did exceptionally well, while many others were poor performers. The sodium dioxide-resistant clones will be further refined and finally propagated.

Experiments with irradiated seeds, microscopically fused germ plasm, and manipulated chromosomes are producing new clones. Fortunately, many choices exist today, especially bred to perform well on city streets.

Politics and People

All of these biodynamic formulae are meaningless if we underestimate the impact of population — too many people on too little open space. The overuse results in soil compaction, vandalism, theft of plants, and vehicular damage. In areas where we want vigorous trees, land-use has to be restricted.

The more critical pressure is politics. Care, renewal, and replanting depend upon budget allocation. Sometimes landscaping budgets depend on whether it is an election year. While trees are a popular sign of loving



Pollutants may seriously inhibit the growth and longevity of urban trees. But susceptibility and symptoms vary with each pollutant and each type of tree, as the table above shows.

Littleleaf Lindens (Tilia cordata)		**Easy to transplant, attractive**
Greenspire	40 ft.	Excellent street tree; perfect shape; upright
Chancellor	40 ft.	Narrow, pyramidal shape
Rancho	40 ft.	Even narrower, upright shape
Callery Pears (Pyrus calleryana)		**Excellent street tree; holds leaves through late fall**
Bradford	40 ft.	Beautiful shape; oval, glossy leaves; fall color
Aristocrat	40 ft.	New strain; better fall color and leaf shape
Chanticleer	40 ft.	Narrower shape
Fauriel	15 ft.	Dwarf; round head
London Plane (Platanus acerifolia)		**Large; broad; not for narrow streets**
Bloodgood	100 ft.	Only anthracnose-resistant strain; adjusted to cold, damp spring season
Pin Oak (Quercus palustris)		**Only easily-transplanted oak; low, sweeping branches**
Sovereign	75 ft.	Only strain with upright branches; suited to streets
White Ash (Fraxinus americana)		**Good street tree; reliable; tough**
Rosehill	70 ft.	Bronze fall color; seedless; oval shape
Autumn Purple	65 ft.	Purple fall color; seedless
Green Ash (Fraxinus pensylvanica)		**Pretty shape; needs less water**
Marshalls Seedless	55 ft.	Rapid growth; drought tolerant; yellow fall color
Summit	60 ft.	More upright; narrower crown; less vigorous
Norway Maples (Acer platinoides)		**All varieties transplant easily; yellow fall color**
Emerald Queen	60 ft.	Upright; oval head; rapid growth
Cleveland	50 ft.	Slower growth
Summershade	60 ft.	Broader; resistant to leaf scorch; rapid growth
Greenlace	50 ft.	Cut-leaf; upright
Crimson King	40 ft.	Wine-colored leaves all seasons; slower growth
Red Maples		**All red maples require more water; red fall color**
Armstrong	35 ft.	Narrow; rapid growth
Autumn Flame	60 ft.	Small leaves; colors and defoliates early
Gerling	35 ft.	Similar to Armstrong; wider shape
October Glory	50 ft.	Green, glossy leaves; globe-shaped; good fall color; (Lately there have been problems with the graft between roots and top stock.)
Red Sunset	50 ft.	Persistent red foliage; pendulous leaves; broad, upright shape; rapid growth

Foresters are breeding clones that will be more tolerant of city stresses. Some of them are described above.

municipal care, they usually take a back seat to more pressing budget needs. Expenditures vary with the pressures of the moment, or what-is-the-squeaky-wheel-today? Well meaning citizens groups are as important as fertilizer in the renewal and care of the urban forest.

The most pernicious aspect of city politics is almost too familiar: bureaucratic incompetence and inefficiency, which are protected by politics, civil service, and unions. How does bureaucracy affect the urban forest? Most tree policy decisions are made by lower-echelon civil servants: a tree superintendent, a tree climber, a chief engineer, a public works commissioner, or a recreation supervisor. They rarely have adequate bioengineering expertise. Sometimes they hold patronage positions.

Furthermore, tree departments are traditionally concerned only with planting, pruning, and removing trees. Planners or city engineers decide on architecture and construction. One understands the growth of plants, the other the growth of cities. Only by combining these skills can they make places where trees will grow.

Ruth S. Foster is a landscape consultant specializing in ecosystem design. She worked for the city of Boston in 1968-69, and again from 1972-76, finally as Assistant Tree Warden. During 1970-71 she was a greenspace planner in Uganda and knew Idi Amin. While there, she designed a garden the elephants wouldn't eat.

Private contracts include institutions, conservation preserves, and homes, including an experimental solar house. A State Registered Arborist, she is urban forestry columnist for *American City and County* magazine, and writes a regular column for the *Boston Globe.* Currently she is at work on a book, *Saving Energy Dollars Through Landscaping.*

Suggested Readings:

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Boston's Urban Forest: The Hazards Are the Same

City tree survival is not simply a matter of good forestry techniques. For example, 90 per cent of the trees in Boston Common are elms. Control of Dutch elm disease requires good sanitation, not unlike control of cholera; timely spraying and immediate removal of diseased trees can prevent the fungus' spread. In fact, recent Forestry Research Station studies show that good control yields a survival rate of 80 per cent after 15 years; with poor control, only 12 per cent will survive.

Each tree costs several hundred dollars to remove, and more to replace. So it is more cost-effective to control the disease and slow the death rate; otherwise removal costs snowball. Washington, D.C., keeps yearly elm losses to 1 to 3 per cent. On Boston's Commonwealth Avenue, under the care of a private tree company, the loss rate is less than 1 per cent. But in nearby Boston Common, Dutch elm losses are 8 per cent and rising. There, civil service inadequacies, union protectionism, low productivity, and limited city budgets are responsible for the demise of trees which have survived 100 years. In the urban forest, politics and protectionism kill more trees than pollution.

The Common is a natural area; much of its original topography remains. Top soil has been added. The loam is deep. There is room for roots to spread and for rain water to percolate into the soil around them. For the first 150 years, from 1728 on, the trees grew tall and strong, helped by the oyster shells (lime) and cow manure (fertilizer) that ended up there.

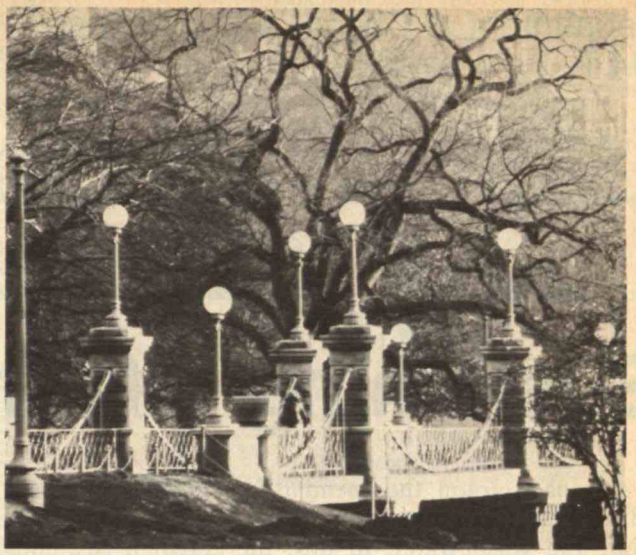
Then "progress" began. Runoff water was put in sewers. The water table lowered. Roots that had been well-watered during summer dried up. "Water stress disease" set in. When paved paths and curbs were added, tree roots were cut and smothered with blacktop or concrete. "Decline disease" set in.

Buildings and playing fields have encroached on the open ground. Construction machinery has compacted the soil. Park Department service vehicles compact it still more with their daily passages over the ground. (One half ton of refuse is picked up daily on the Common, and half is disposable cans and bottles.)

Trees are sacrificed for unnecessary and expensive granite curbing — more suited to superhighways than to the oldest park in the country. Engineered paths are planned through trees rather than around them. It's ironic that in the year of the Bicentennial, over 300 trees were donated to the city by caring citizens, while the park engineer removed 50 for the convenience of contractors who were putting in new walks and more sewers. It is not surprising that few of the younger trees on the Boston Common show promise of matching the giants of earlier years. However, in most open park areas, the urban forest can survive well enough if not subjected to construction damage, overuse, or municipal neglect.

Survival on city streets is a different matter. A tree planted in a small hole in the concrete, in a cubic foot of topsoil, with little water, automobile damage, and salt poisoning is not a candidate for robust growth. In a 1976 survey of crowded Beacon Hill, the average age of its 503 live trees was 8.08 years. Ten years earlier, in 1966, the average age of the Hill's 215 trees was 16.8 years. Of those 215 trees, only 139 were alive in 1976 — a loss of 35 per cent in ten years.

A look at survival on individual streets is even more telling. We know that Beacon Street in the Back Bay was planted with lindens in 1910 by a neighborhood committee. Mrs. Frederick Lord wrote in proper Victorian, "Will you not contribute towards this well-considered, desirable and permanent improvement of Beacon Street?" In 1937, a follow-up study reports, "How thriving the trees are. We did not dream they would be injured more by collision with vehicles than by horses. You remember, we were afraid the horses would gnaw off the bark." The sidewalks were brick, so air and water could reach the trees' roots. Each tree cost about $40 including transportation, Victorian coffee breaks, and planting. Today the cost would be $200.



Trees in Boston's Public Garden are not exempt from the assaults of disease, construction, pollution, and vandalism that plague the city's urban forest. Still more destructive are a swollen bureaucracy and limited budget. (Photo: Peter Dreyer)

How permanent was Mrs. Lord's improvement? In 1976, 66 years later, only 90 of the original 350 trees remained, a survival rate of 26 per cent. About half of them are dying or sickly. There are only 27 young trees on the street; municipal tree planting has not kept pace with losses.

On nearby Boylston Street, recently planted trees have not fared so well. Of 150 trees planted within the last six years, 25 per cent are dead or dying. Of the remaining 113, half are in poor health. Ninety-seven of the trunks bear scars from auto damage. Almost half the trees' lower branches have been broken by trucks (or vandals — a major problem near schools and playgrounds). City trees that do not branch at least 7 to 10 ft. from the ground are always hit by passing trucks and swung on by playful passers-by.

Although staking is traditionally considered a necessity, in the city stakes are most often broken and actually hurt the trees. There are 19 staked trees on Boylston Street, and they are all being damaged by their stakes. Many of the trees are holding up the stakes, instead of vice versa. The wires of other stakes are cutting into the bark. So in the city, stakes just make more work. Heavy metal pipes at curbside would provide better protection from trucks, car bumpers, and doors. (Auto wounds allow fungus disease to enter, often the cause of death in several years.)

Obviously, the best place for trees is not at curbside, where they are almost always planted. There used to be a grass strip between the sidewalk and the road where trees were traditionally planted. The grass strip has disappeared, but the tradition continues.

Survival statistics show that we need not be limited to the commonly used, long-lived hardwood species. Any fast growing tree is useful. Boston and other cities would do well to plant — well away from curbside — lower growing, less expensive crabapples, fruitless cherries, and pears. These trees are especially needed where utility wires can't be avoided. While their life expectancy is only 30 to 50 years, that is more than adequate for urban trees given their present ten-year survival rate. — *R.F.*

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A space colonist's life may approach one of total recycle. Maintaining the space ecosystem may be a tricky proposition.

Sustaining Life in a Space Colony

In aerospace jargon, the essentials for human survival are called the *life support system* (LSS): air, drinking water, food, and wash water. In this, the era of a two-hour transcontinental flight, travel time has become so compressed that few of us have ever considered how much food and water we would need to survive for an extended time were we to be denied the convenience of resupply. Only under circumstances of extended sea voyages was it necessary to estimate, store and carry the required food and water.

Recently, the beginnings of space exploration and the introduction of the nuclear submarine have refocused attention upon the magnitude and scope of sustaining humans without benefit of earth and earth-supplied resources. This article describes some of the approaches to the development of LSS for the case of a space colony or, in more general terms, for a large number of people living in a closed environment for a relatively long period.

The Life Support System

The inputs of LSS are air, drinking water, food, wash water and sanitary water (*see table on p. 38*). The main outputs are urine, feces, carbon dioxide and wastewater. The state-of-the-art of LSS is represented by submarine and space-flight technology. In applications to date, the essential ingredients have been brought on-board before the flight or voyage and wastes have either been accumulated for later disposal or dumped overboard.

For long-term space journeys, it is desirable to replenish or recycle supplies on board. The cost of supplies required for the journey is proportional to their weight at launch. Since the quantities of supplies required increase with the duration of the flight, at some breakeven point it will be less costly to send up the equipment to recycle the supplies from wastes than to use up the provisions on a once-through basis.

Let us look, for example, at wash water which is relatively easy to recycle because the contaminant levels are low (ca. 350 ppm; Putnam, 1975). A number of processes have been investigated for wash water recycle, including systems based on multifiltration, ultrafiltration, reserve osmosis and vapor compression distillation (Putnam, 1976). A schematic of a system based on reverse osmosis (RO), with vapor compression distillation (VCD) to concentrate the rejected wastes, is shown on p. 40.

Even a recycling system such as this requires that replacement filters, membranes, and chemical additives be brought from earth, with their quantity depending on the length of the flight. Thus the total weight at launch of the system increases with flight duration.

For a six-person crew, launch weight as a function of flight duration is shown in the figure on p. 41 for state-of-the-art as well as projected technology. Also shown is the launch weight of an alternative system, multifiltration, based on sequential filtration with cartridge filters, activated carbon and ion-exchange resins. Based on current knowledge, an RO-type of system for wash water recycle would probably be preferred for a space colony.

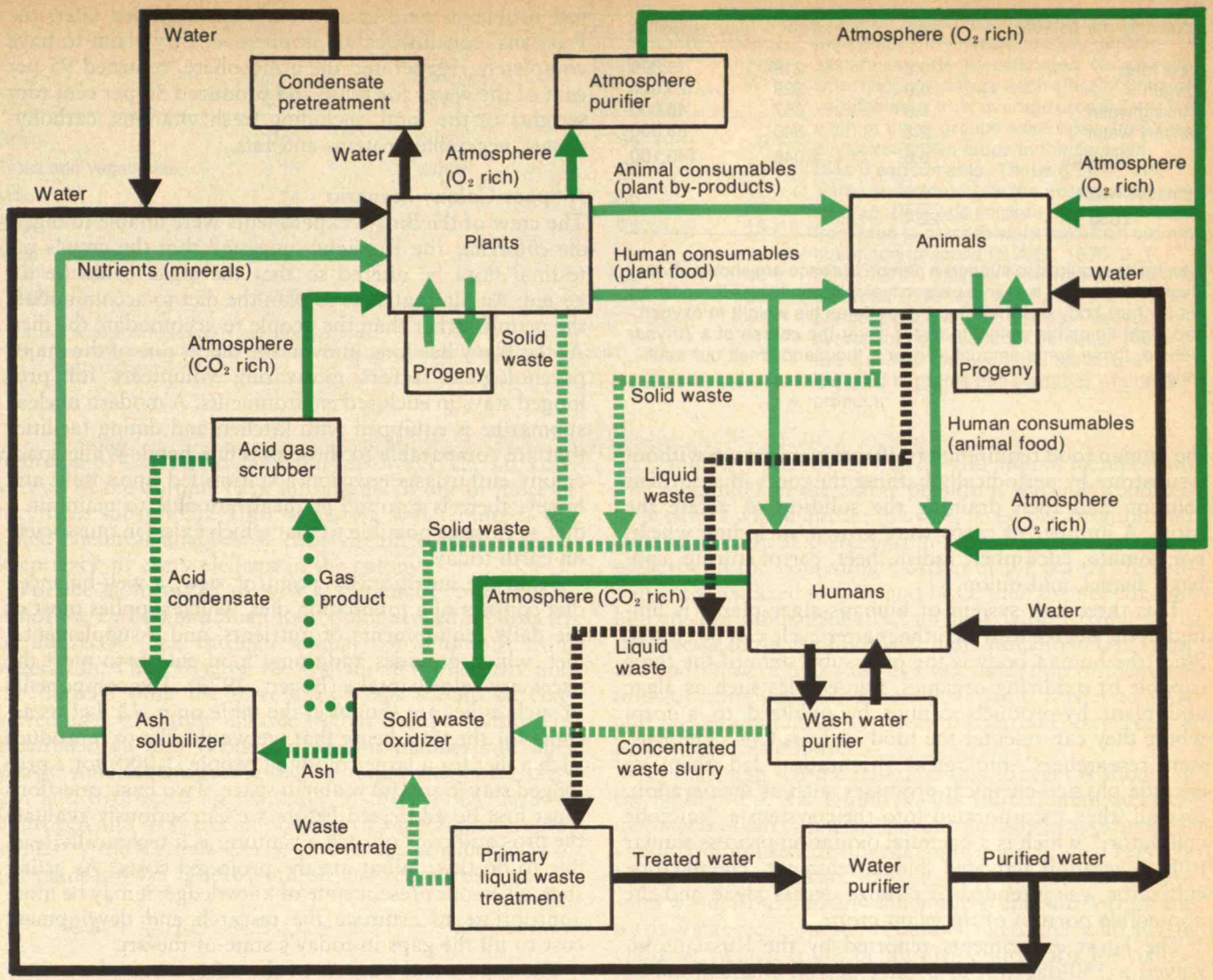
Human wastes and other organic wastes (food wastes and trash) can be turned into carbon dioxide, water, and ash by presently available methods. Wet and dry oxidation systems have both been built and tested on a demonstration scale. In wet oxidation, an aqueous slurry is treated at moderate temperatures (150-250°C) under high pressures (1,200-2,200 psig) (Jagow, 1972, 1976). In dry oxidation, toilet wastes and aqueous slurries of pulverized trash are first concentrated by evaporation of water, and the concentrate is then incinerated (Schelkoof, 1974). Water vapor and off-gases from the incinerator are passed through catalytic oxidizer beds to completely convert organic contaminants to CO_2 and H_2O.

A number of physico-chemical techniques have been suggested for recycling oxygen from CO_2 (Reid, 1970; Quattrone, 1973). These methods involve separation of CO_2 from air followed by reaction of CO_2 to produce O_2 and carbon by-products (methane in the Sabatier process or solid carbon in the Bosch process). However, processes of this type are not suitable for a *closed ecological life support system* (CELSS) for flights of long duration. While oxygen is generated for reuse, the carbon present in the food consumed is ultimately converted to a solid form and must be stored. To close the system, the carbon must be returned to the food cycle from which it originated.

Controlled Environments for Plants

So far very little research has been devoted to the problem of returning the recaptured carbon to the food chain, although such an accomplishment will be necessary if the life support system is to be completely closed. No prior space missions have encompassed such an ambitious objective, nor are there any prototypes on earth on which to build. As far as we know, the most direct method of converting carbon into food is by plant photosynthesis, the chemical reaction being the inverse of animal metabolism.

Growing plants in controlled environments is an active field of research; most plant research laboratories are now equipped with *phytotrons* — enclosed chambers with controlled temperature, humidity, intensity and



The cost of supplies required for a long-term space voyage is proportional to their weight at launch. Since the quantities of supplies required increases with flight duration, for long voyages it will be less costly to recycle supplies than to use up provisions on a once-through basis; ideally, the environment would be closed, and completely self-sufficient. A schematic for a proposed system for a closed environment life support system is shown above.

periodicity of illumination and, in some cases, CO_2 concentration in the atmosphere (Downs, 1975; Downs and Hellmers, 1975). Inert cultural substrates such as sand, gravel and vermiculite are usually perferred over soil. In *hydroponics,* the substrate is eliminated completely, and the plant stems are supported by a sheet of material overlying an aerated nutrient solution in which the roots are submerged. In hydroponics or when using an inert cultural medium, nutrients are supplied by an aqueous solution consisting of a mixture of inorganic salts.

Bios-3

The most advanced research to date in CELSS is the effort of a group at the Biophysics Section of the Institute of Physics of the U.S.S.R. Academy of Sciences (Gitel'son, et al., 1975). The focus was to develop methods of closing the cycle with biological processes. Starting with a relatively simple concept for regenerating human metabolic wastes, they added complexities to improve the degree of closure of the system. Their studies date back to the mid-1960s when they explored the use of algae to regenerate human metabolic wastes in a closed environment. The atmosphere from a compartment containing one man was fed to an algae cultivator bath, where oxygen was regenerated from carbon dioxide. Urine and domestic water was also fed to the algae cultivator, while water vapor was condensed from the algae compartment, filtered with activated carbon, and recycled to the manned compartment. *Chlorella* was chosen as the algae species, in part, because the biochemical composition fulfills many of the human nutritional requirements. The daily harvest contains all of the essential amino acids, practically a full set of vitamins, sufficient lipids and a number of minerals. Thus, the initial intention was to use the algae as a food source. However, the research found that "direct use of *chlorella* as an animal feed or as a human food did not produce favorable results."

In subsequent studies, a phytotron was incorporated in the test chamber to share with the algae the task of regenerating the atmosphere, and to provide a portion of

Inputs (kg. per person)	Day	Year	Lifetime
Food (dry)	0.6	219	15,300
Oxygen	0.9	329	23,000
Drinking water	1.8	657	46,000
Sanitary water	2.3	840	58,800
Subtotal	5.6	2,045	143,100
Domestic water	16.8		
Total	22.4		

The inputs required to support a person in space are shown above. Over the course of a year, a person typically consumes three times his (or her) body weight in food, four times his weight in oxygen, and eight times his weight in water. Over the course of a 70-year lifetime, these items amount to over a thousand times our adult weight.

the human food requirements. Plants were grown without a substrate by periodically bathing the roots in a nutrient solution and then draining the solution to aerate the roots. A number of crops were grown, including wheat, rye, tomato, cucumber, radish, beet, carrot, turnip, cabbage, fennel, and onion.

This three-link system of humans-algae-plants is limited in the degree to which the matter cycle can be closed. Since the human body is the only subsystem of the three capable of oxidizing organics, non-edibles such as algae and plant by-products cannot be oxidized to a form where they can re-enter the food cycle as CO_2. The Russian researchers' biological orientation led them to exclude physico-chemical processes such as incineration. Instead, they incorporated into their system a "microbe cultivator," which is a bacterial oxidation process similar to high-aeration activated sludge treatment. The microbe cultivator was intended to oxidize excess algae and the non-edible portion of the plant crop.

The latest experiments reported by the Russians involved a 180-day test in a three-person chamber called the "Bios-3" (Gitel'son, et al., 1975). Although some critical problems were encountered, as explained later, the Russians' conclusions are impressive: they claim to have completely regenerated the atmosphere, returned 95 per cent of the water for reuse and produced 30 per cent (dry weight) of the food, including fresh vitamins, carbohydrates, vegetable proteins and fats.

A Space Colony Scenario

The crew of the Bios-3 experiments were unable to digest the *chlorella;* the Russians suggested that the crew's intestinal flora be altered so that the algae could be digested. An alternative is to plan the diet to accommodate the people rather than the people to accomodate the diet. As the Navy has long known, the diet is one of the major psychological factors motivating volunteers for prolonged stays in enclosed environments. A modern nuclear submarine is equipped with kitchen and dining facilities that are comparable to those of a fine hotel. While space colony enthusiasts envision a station fed upon milk and honey, there is a sound medical rationale to maintain a diet as close as possible to that which exists in our society on earth today.

From the nutritionists' point of view, a well-balanced diet consists of a foundation diet, which supplies most of the daily requirements of nutrients, and a supplemental diet, which provides additional food energy to meet the necessary caloric intake (Bogert, 1973). The components of such a diet are shown in the table on p. 42. Let us assume for the time being that we would like to reproduce such a diet for a large colony of people (1,000) for a prolonged stay (5 to 100 years) in space. Two basic questions must first be addressed before we can seriously evaluate the pros and cons of such a venture: is it technically feasible to do this? What are the projected costs? As a first step, given our present state of knowledge, it may be more appropriate to estimate the research and development cost to fill the gaps in today's state-of-the-art.

The inputs and outputs of the subsystems of a colony housing people, animals, vegetation are shown in the

	Biochemical components (per cent dry)							Minerals (per cent dry)				
Vegetable and place grown	Total nitrogen	Crude protein	Nitrogen-free extractive matter: Sugar	Nitrogen-free extractive matter: Other	Cellulose	Fats	Ash	P	K	Ca	Mg	S
Carrot												
Field	1.4	8.7	51.5	25.27	7.3	0.63	6.6	0.52	2.60	0.36	0.22	0.19
Phytotron	1.8	11.2	42.3	31.23	8.8	1.47	5.0	0.44	1.70	0.41	0.20	0.22
Beet												
Field	2.3	14.4	63.0	6.88	6.4	0.22	9.1	0.44	3.66	0.24	0.37	0.22
Phytotron	2.8	17.5	53.0	12.98	7.6	0.62	8.3	0.48	3.50	0.37	0.36	0.26
Radish												
Field	2.5	15.6	24.2	38.57	8.0	1.13	12.5	0.60	6.00	0.56	0.26	0.47
Phytotron	2.2	13.7	28.7	34.25	8.8	0.25	14.3	0.68	6.10	0.60	0.36	0.51
Turnip												
Field	2.6	16.2	37.7	28.89	6.8	1.31	9.1	0.58	4.40	0.46	0.23	0.69
Phytotron	2.2	13.7	40.0	28.60	7.8	2.20	7.7	0.58	2.65	0.46	0.23	0.59
Tomatoes												
Field	3.3	20.6	29.4	31.60	8.4	—	10.0					
Phytotron	2.9	18.1	20.8	40.10	9.9	—	11.1					
Cucumbers												
Field	2.5	15.6	28.3	35.99	8.1	0.91	11.1					
Phytotron	3.9	24.4	16.8	37.58	9.0	1.22	11.0					
Onions												
Field	4.0	25.0	36.5	12.25	7.6	1.95	16.7					
Phytotron	3.5	21.9	31.3	21.30	6.5	—	16.0					

	Per unit of production		Per adult daily diet[1]	
	Biomass ($g/g\ day^{-1}$ FEP)[2]	Area ($m^2/g\ day^{-1}$ FEP)[2]	Biomass (kg)	Area (m^2)
Grain	700	0.056	65	5
Fruits and vegetables	15	0.008	20	10
Milk	34		350	25
Eggs	44		25	15
Meat				
Chicken or	100		500	40
Beef	2,200		1,500	80

[1] See table on page 42 for amount of each food type in diet.
[2] FEP is fresh edible product. For animal products, the resources required for feed are not included in columns 1 and 2; they are included in columns 3 and 4.

The area and illumination required to grow the plants and animals of a life support system can only be estimated. No attempt was made to analyze each class of grain or vegetables or fruit; average growth rates for each of these groups were taken from the phytotron-grown crops in the Russian Bios-3 experiments. These growth rates were used to calculate the average biomass hold-up. Beef and chicken conversion rates from feed to carcass were based on current husbandry practice (N.A.S., 1975; J. T. Reid, 1970). Chicken feed was assumed to be grain, while beef feed was taken as 50 per cent grain and 50 per cent vegetation byproduct non-edible for humans. The first two columns represent the resources required in grams per gram/day of edible product.

figure on p. 43. The fundamental task of recycle is to convert all of the outputs back into inputs of one or more of the three subsystems. Ultimately, we will require a detailed chemical analysis of each stream so that we can keep track of every element in the colony.

For the moment, let us look at the major components. All of the carbon in human food originates either directly or indirectly (i.e., through animal consumption) from vegetation. Thus, to close the system, all of the carbon in the outputs from the three subsystems should be converted back to carbon dioxide so that it can be photosynthesized back into vegetation. In this manner, we shall satisfy simultaneously the recycle requirements for oxygen and hydrogen. For example, if the average carbon, hydrogen and oxygen composition of vegetation is represented by the formula CH_mO_n, then the stoichiometry of net plant growth (photosynthesis less respiration) is:

$$CO_2 + \frac{m}{2} H_2O = CH_mO_n + (1 + \frac{m}{4} - \frac{n}{2}) O_2$$

A portion of the edible plant output is oxidized back to CO_2 and H_2O directly by human and animal metabolism. The remainder of the edible portion is partially oxidized to products which appear in urine, feces, perspiration and exhaled breath. If these partially oxidized products, together with the non-edible portion of the plants are subsequently oxidized to CO_2 and H_2O, then the net effect of human and animal metabolism plus waste oxidation is the reverse of the net photosynthesis stoichiometry. Thus, incorporation of a process like wet oxidation or incineration for complete conversion of organic wastes to CO_2 and H_2O simultaneously closes the carbon, oxygen and hydrogen recycle loop.

A processing scheme based on this concept is shown in the figure on p. 37. Liquid wastes from human and animal metabolism could be concentrated by evaporation or vapor compression distillation in the unit labeled Primary Liquid Waste Treatment. The concentrate, along with solid waste from humans and animals and slurry from the wash-water recycle system could be fed to the Solid Waste Oxidizer, which could be an incinerator. Air for oxidation could be withdrawn from the human and animal compartments. By so doing, the air would be sterilized and organic contaminants in the atmosphere could be removed simultaneously. The off-gas from the Solid Waste Oxidizer would contain acid gases (e.g., sulfur and nitrogen oxides), which could be removed in an Acid Gas Scrubber prior to passing the CO_2-rich atmosphere to the phytotron. The ash from the Solid Waste Oxidizer would contain sodium chloride and most of the elements required for the plant nutrient medium. The metals in the ash will be present as oxides, most of which have limited solubility in water. Thus, the sodium chloride might possibly be extracted selectively by mild aqueous treatment. The remaining oxides can be solubilized by extraction with the condensate from the Acid Gas Scrubber.

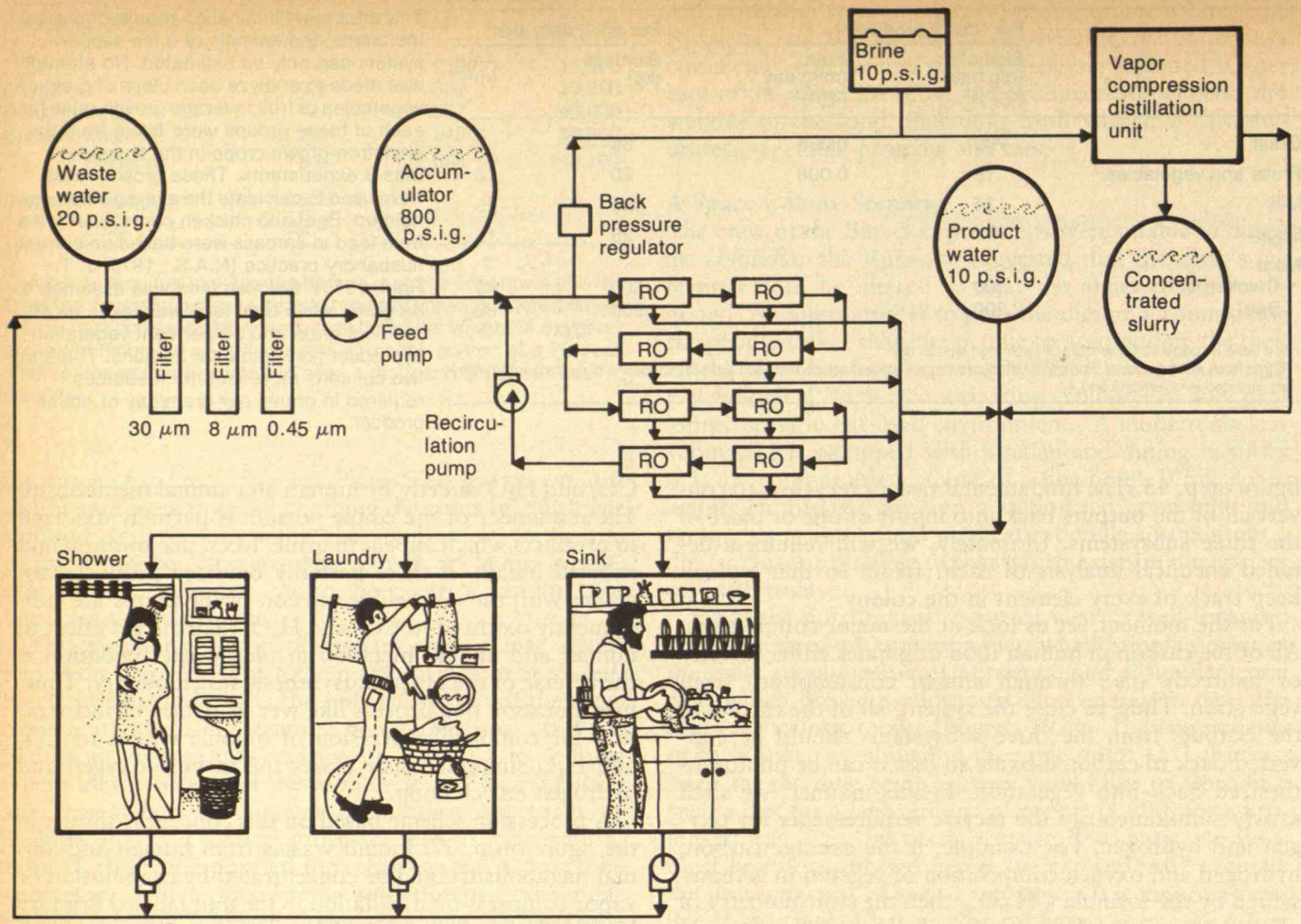
The "total cost" of such a system is related to the resources required for development, construction and launching. The last factor is, in turn, related to the weight of the system (biomass and hardware) and its demand on the resources of the space station or colony in terms of power, volume, area for illumination, area for heat rejection, etc. The resources, in turn, depend upon the current and projected state of technology. In other words, there is a trade-off between the costs of developing such a system in order to reduce the launch cost and the use of state-of-the-art technology with a higher launch cost.

To gain a feel for the order of magnitudes involved, rough estimates are shown in the table above for the biomass and area of illumination necessary to produce

Trace elements (mg/kg dry)

Mn	B	Cu	Zn	Mo	Al	Cr	Ni
20.6	53.3	2.8	10.0	0.1	106.0	0.6	0.6
17.5	42.5	3.0	19.0	0.6	75.0	1.6	1.5
34.5	23.6	8.0	15.4	0.1	50.9	0.9	0.9
37.4	27.5	8.4	17.5	0.8	91.7	2.4	1.8
18.8	53.8	1.3	15.0	0.1	375.0	1.4	0.9
7.4	58.6	2.3	2.9	1.0	58.6	2.4	2.4

Little is known about the effects of controlled environments on the level and distribution of nutritional components. The table shows a comparison of field- and phytotron-grown crops made by the Russian Bios-3 team. These results indicate the changes in biochemical composition between the two growing methods to be minor, although some trace elements show significant variations.



Waste water, which is relatively simple to recycle, might be purified through the system shown above. Waste water from a storage tank is passed through progressively finer cartridge filters to remove particulates that can foul the reverse osmosis (RO) membranes. The filtered water enters a recirculation loop of RO modules, where the water that permeates the membranes is collected and stored at pasteurization temperature. The concentrated "brine" is sent to a vapor compression distillation (VCD) unit which reduces the contaminants to a concentrated slurry, either to be stored on-board or processed further.

the daily requirements of the adult diet.

While these estimates should be taken with a grain of salt, they are interesting from several points of view. Clearly, fresh beef will be a rarity on early space colonies. It requires over 1.0 kg of biomass in-process to produce enough food to fulfill a daily requirement of the order of 0.2 kg. The breakeven point for once-through versus recycle, based on biomass alone, is 1,500 kg/.2 kg day^{-1} = 7,500 days, or about 20 years. That is, for stays of less than 20 years, it is less costly to launch stored beef than to raise cattle (provided, of course, that a means for storing beef for 20 years can be developed and launched at a reasonable cost). Chickens will be somewhat less costly (500 kg biomass versus 1,500 kg for beef), although 500 kg does not appear to be prohibitive when compared to biomass required for milk (350 kg). There are some indications that rabbits may be as efficient as chickens in converting feed to meat, and fish culturing may be even more efficient (Johnson and Holbrow, 1977).

It is also interesting to compare the productivity of phytotron-grown crops with those grown by traditional means in the field. For example, wheat production in the U.S. in 1972 averaged 32.7 bushel/acre, which is equivalent to 0.3 m^2/g day^{-1}. It has been projected that wheat yield could reach 93 bushel/acre for an irrigated field by the year 2000 (N.A.S., 1975), but that is still a factor of two less than the currently obtainable yield in a controlled environment.

The Unknowns

Within the limits discussed above, the technology to close the *gross* material balance appears to be available. There is still much to be explored to close the material balance of the remaining 100 elements. While the overall uptake of elements in plants can be determined by monitoring the inputs, we know little about their concentrations in the non-edible parts of the vegetation.

Within the edible portions of plants and vegetables, very little is known about the effects of controlled environments on the level and distribution of nutritional components. In a test conducted by the Russian Bios-3 team, some components were analyzed and compared for phytotron and field-grown crops. Some of their results are given in the table at the bottom of pages 38-39 (Gitel'son, et. al., 1975). There are some changes in biochemical composition, but these were of minor importance; with the exception of protein where amino acids are not equivalent in nutritional requirements, the biochemical components are largely interchangeable between food types. (In a separate analysis of amino acids, the total did

MIT '77

Articles

Departments

A Bullish Report on Jobs: Recruiting and Offers Up, Salaries Rising Faster than Inflation

If 1976 was a good year in which to graduate from M.I.T. — with almost any degree, in almost any field — 1977 promises to be even better.

When everyone's returns were finally tabulated last fall, says Robert K. Weatherall, Director of Career Planning and Placement, less than 10 per cent of the members of the Class of 1976 were reported as unsettled in their plans or still seeking employment. That's the lowest figure since the Class of 1970. The proportion of seniors taking jobs in industry after receiving the S.B. degree rose to 18 per cent, more than any year since 1969; 67 per cent went on to graduate school at M.I.T. or elsewhere. Those interested in a graduate degree included 102 who applied to enter medical schools. Of the latter, 81 (just under 80 per cent) were accepted by at least one of the institutions to which they applied; that's more than double the national average of 36 per cent.

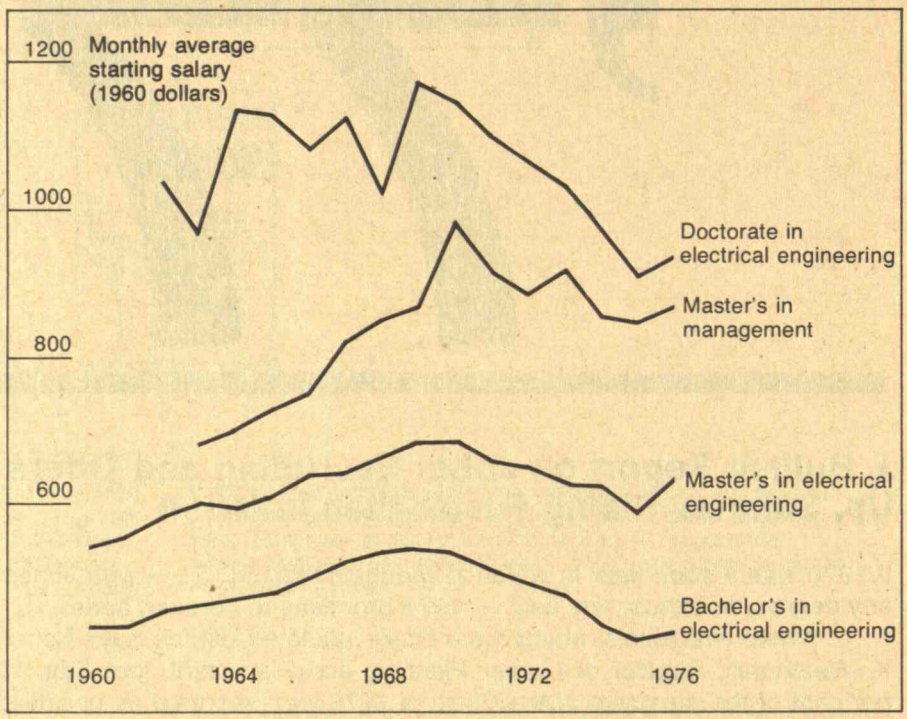
Mr. Weatherall says all these bullish trends seem to be continuing for the Class of 1977. Recruiters have given the Career Planning and Placement Office a very busy spring, and salary offers to the Class of 1977 seem to be up by 6 to 8 per cent, rising slightly faster than the rate of inflation for the second year in a row (*see chart*).

. . . "a fast track to the top" in positions "which are often close to the decision-makers."

In all this good news, the only dark cloud hovers over graduates in architecture, which Mr. Weatherall says is "the field with the most difficult employment picture." He notes with surprise that M.I.T. enrollments in architecture have increased in each of the last three years, but job prospects remain bleak because many architectural firms are retrenching in an era when construction costs are up and the building industry depressed.

At the other end of the scale is the Sloan School of Management, where Mr. Weatherall describes the demand for graduates as "very strong," offering for many of them "a fast track to the top" in positions "which are often close to the companies' decision-makers." Starting

"While economists were making up their minds last year whether the economy was back on an upward path, the market for M.I.T. graduates in the Class of 1976 seemed to leave little doubt of the answer," says Robert K. Weatherall, Director of Career Guidance and Placement, in his annual report. One piece of his evidence: for the first time since 1970, starting salaries offered to M.I.T. graduates entering industry went up faster than the inflation rate. The chart shows average monthly starting salaries of M.I.T. graduates in management and electrical engineering (in 1960 dollars: the deflator used was the Consumer Price Index). Starting salaries for graduates of 1976-77 are up another 6 to 8 per cent — growing faster than the rate of inflation for the second year in a row, says Mr. Weatherall.



salaries for students who received master's degrees from the Sloan School in 1976 but had no business experience averaged $18,600, and offers have gone up apace since then.

There's also an active demand for engineering graduates, and most of those in the Class of 1977 have many opportunities from which to choose — "the easiest year since 1969," Mr. Weatherall says. That's especially true of students with doctor's degrees in engineering, who are "recruited in a style approaching that" of master's degree recipients from the Sloan School. He cites the case of one doctorate in machine design (1976) who received 13 job offers with salaries between $21,000 and $26,000. "A student who pursues his interest in engineering to the doctorate by no means diminishes his usefulness in industry or his chance of rising to the top," says Mr. Weatherall.

Industrial jobs are preponderantly the choice of M.I.T. engineering graduates — at all levels — who are not continuing for the next highest degree. Of those taking jobs after receiving engineering degrees in 1976, some 9 per cent went to work in government, about 27 per cent joined government contractors, and 64 per cent joined commercial firms in jobs involving the design, development, or manufacture of commercial products. Most M.I.T. engineering graduates opt for jobs in fields involving what Mr. Weatherall calls "dynamic" technology — where engineering methods and applications are changing fastest. — *J.M.*

Should thursday *continue to be a recognized student activity after its foray into sensationalism (or sexual politics, as some saw it)? After an open forum and a formal hearing, officers of the Association of Student Activities (above) put* thursday *on probation for what they considered a "serious invasion of privacy." If it happens again,* thursday *could lose its space in Walker Memorial and the few other prerogatives it enjoys as an official student activity. (Photo: John M. Grunsfeld, '80, from* The Tech*)*

"Consumer Guide to M.I.T. Men" Provokes a Furor

An attempt at outrageous humor provoked a furor and attracted international media attention this spring when two M.I.T. women students published a "Consumer Guide to M.I.T. Men" in *thursday,* M.I.T.'s "alternative" student newspaper (not to be confused with the traditional bi-weekly, *The Tech*).

On the basis of their sexual experiences at the Institute, Roxanne Ritchie, '78, and Susan Gilbert, '78, "rated" 36 M.I.T. men according to their performance on a zero-through-four-star scale, complete with brief, explicit, raunchy explanations. Diane White of *The Boston Globe,* while admitting that the prank "was indefensible on a number of grounds, not the least of which is good taste," felt they had succeeded in their intent, "producing a highly magnified, albeit distorted, mirror image of the sort of thing that men have been doing to women for years."

Reactions were intense.

President Jerome Wiesner expressed the indignation of the community with a statement on the front page of *Tech Talk,* denouncing the "gross violation of our norms of taste and regard for privacy. I share this sense of revulsion and am deeply concerned at the evidence of the absence of editorial control at *thursday* with respect to matters of taste, possible libel, concern for veracity, and the human sensibilities of others on this campus."

The administration brought disciplinary charges against the authors of the article on the grounds of invasion of privacy and questioned *thursday*'s right to remain a recognized student activity. Still, some angry requests that the students and *thursday* be suspended immediately were heard. Such drastic action is beyond the established jurisdiction of the administration, according to President Wiesner. A student-faculty committee determines the measures to take, he said, and "there is no basis for violating this tradition in the present situation."

Student opinions varied; many wrote emotional, angry letters to the student newspapers. But others stood in defense of the article — the more extreme view labeled it "superb journalism." Some said it was "entirely unwarranted to consider the closing down of *thursday* . . . [which] serves a valuable purpose to the community by discussing controversial issues." ("You need not pick up a copy if you don't wish to risk being offended.")

The two authors say they have received threats, obscene telephone calls, and harassment and were asked by their landlord to move out of their Cambridge apartment.

And the media had a field day. When Associated Press and United Press International picked up the story it spread to major newspapers and magazines throughout the United States, local television stations in New York and Washington, and newsweeklies around the world.

The staff of *thursday* responded to the brouhaha with a collective statement expressing an apology "to all those whose names were used without their knowledge or permission." They agreed to seek permission of indi-

viduals to use their names in stories that involve private matters. But they added, "We will not be censored by anyone at any time." Feature Editor Scott Batterman, '77, felt compelled to publish a more personal apology for writing that he termed tasteless, worthless and humorless: "I may have once been laboring under the delusion that I was amusing someone; now I'm sorry for having wasted your time . . ."

Disciplinary Action: Suspension and Probation

The four principals — the two authors, Mr. Batterman, and John Roselli, '77, Editor of *thursday,* were called before the Faculty Committee on Discipline. The Committee's charges and decisions are by policy confidential, but John Roselli told the *Globe* that Ms. Ritchie and Ms. Gilbert were placed on formal probation (a notation of disciplinary action will be on their permanent school records for ten years); Mr. Roselli was placed on internal probation (no notation will go on his record unless he is involved in further disciplinary incidents); Mr. Batterman was suspended for three months. (Since he is a senior, his S.B. was in effect postponed until the fall.)

The Association of Student Activities (A.S.A.) also reviewed complaints filed against *thursday.* (The A.S.A. can revoke the status of *thursday* as a recognized student activity, which would cause the organization to lose its M.I.T. space.) The A.S.A. censured the newspaper for "excessive invasion of privacy. . . . We feel that an incident of this nature should never recur. Therefore, if any activity is guilty of an invasion of privacy, the A.S.A. shall take extreme action against said activity, up to and including the removal of M.I.T. affiliation." — *M.L.*

Learning Chinese at Wellesley is "like jumping off a log," said one M.I.T. student after a course with Professor Helen T. Lin. (Photo: Chalue from Wellesley College)

The Wellesley Exchange: Realizing Its Goals — " . . . Change of Pace," "Different Point of View . . ."

After nine years, the Wellesley-M.I.T. exchange program "is in the best state of health it has enjoyed since its inception," says Professor Kenneth M. Hoffman, Co-Chairman (for M.I.T.) of the effort.

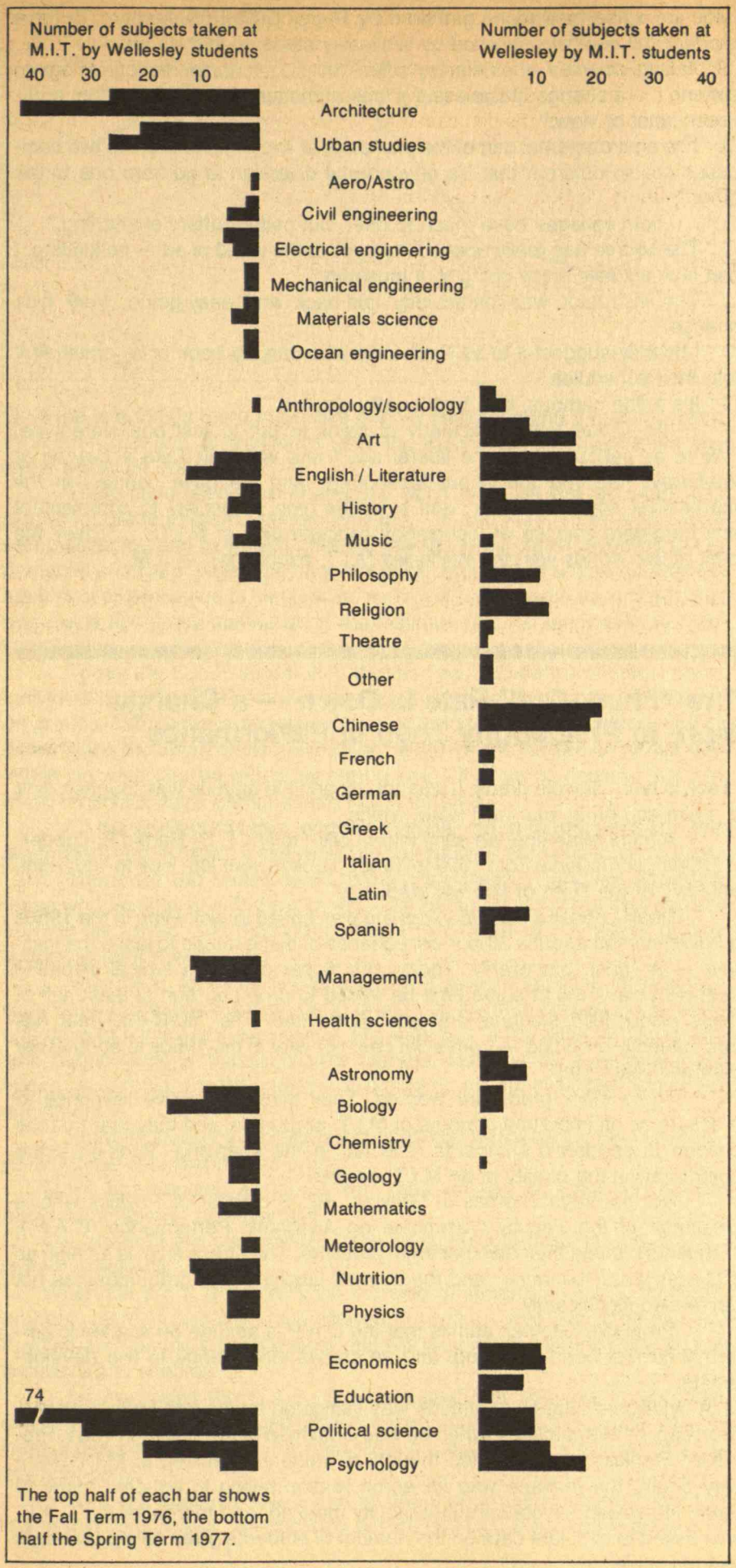
By that he means that M.I.T. and Wellesley students are in fact using the program effectively for its intended purposes: to give students the advantages of complementary faculty strengths at the two institutions and of their contrasting environments — the urban atmosphere of M.I.T. and the suburban (almost rural) setting of Wellesley. Some 222 Wellesley students took 243 M.I.T. subjects this spring, and 158 M.I.T. students were registered for 178 Wellesley subjects.

In addition, Professor Hoffman wrote in a report for the Committee on Educational Policy this spring, M.I.T. is realizing some special benefits:

☐ Cross-registration of Wellesley students is providing M.I.T. with "a source of highly capable women graduate students." The case in point is architecture, where "numbers of Wellesley students have used the opportunity to register for undergraduate M.I.T. subjects to prepare themselves" for graduate work at the Institute. The Schools of Engineering and Management are now trying to add Wellesley registrants for similar programs.

☐ Academic cooperation has enriched the M.I.T. curriculum in several fields. Wellesley's Chinese Department offered two courses at M.I.T. — Advanced Elementary Chinese and Chinese Literature in the 20th Century — in 1976-77, and there will be a beginning course in Chinese especially for M.I.T. students next year. Wellesley courses in political science have been given in alternate weeks on each campus. Wellesley faculty have taught courses in French and Far Eastern religions at M.I.T.

M.I.T. students who have tried exchange classes are enthusiastic.



The top half of each bar shows the Fall Term 1976, the bottom half the Spring Term 1977.

The M.I.T.-Wellesley exchange is working "just fine," says Professor Kenneth M. Hoffman, Head of the Department of Mathematics who is the exchange's Co-Chairman (for M.I.T.). By that he means that students are in fact capitalizing on the academic and physical diversity of the two institutions, M.I.T. students traveling to Wellesley for courses they can't get at the Institute and Wellesley students coming to Cambridge for studies not given on their campus.

Here are some quotations gathered by Peggy O'Neil (Wellesley '77) for a promotional booklet published by Wellesley students this spring:

☐ "Taking courses at Wellesley offers us . . . a nontechnological atmosphere, . . . a change of pace and a look at matters and subjects from a different point of view."

☐ "The environmental part of the exchange is important to me; the two campuses are so different that it's a wonderful diversion to go from one to the other."

☐ ". . . both colleges have much to offer, but neither offers everything."

☐ "The course has really opened my eyes to the world of art — no kidding. I can now actually enjoy going to a museum."

☐ "The instructor was particularly laid-back and easy-going. Very nice change."

☐ "I heartily suggest it to all Tech tools who can, by hook or by crook, fit it into their schedules."

☐ "It's a fine campus, with high quality classes."

Ms. O'Neil was particularly at pains to put to rest one stereotype: "We're as serious about the liberal arts," she writes in *Take a Course at Wellesley,* "as you are about technology, and we have courses in the humanities, social sciences, and sciences (yes, *sciences)* to complement any hard-core science or technology concentration at M.I.T. . . . Enjoy the best of two worlds with the Wellesley-M.I.T. exchange!" — *J.M.*

The "Flunk-Out" Rate Is Down — a Change More in Philosophy Than in Performance

"Tech is hell," say old grads. It *was* tough; and the attitude was tougher: sink or swim and bring your own water wings.

Alumni remember an early introduction to M.I.T. by Harold E. Lobdell, '17, Dean of Students from 1929 to 1946: "Look to your left; look to your right; only two of the three of you will graduate."

Only 6 per cent of a typical incoming freshman class will at some time be forced to drop out, and at least half of these disqualified students are later readmitted.

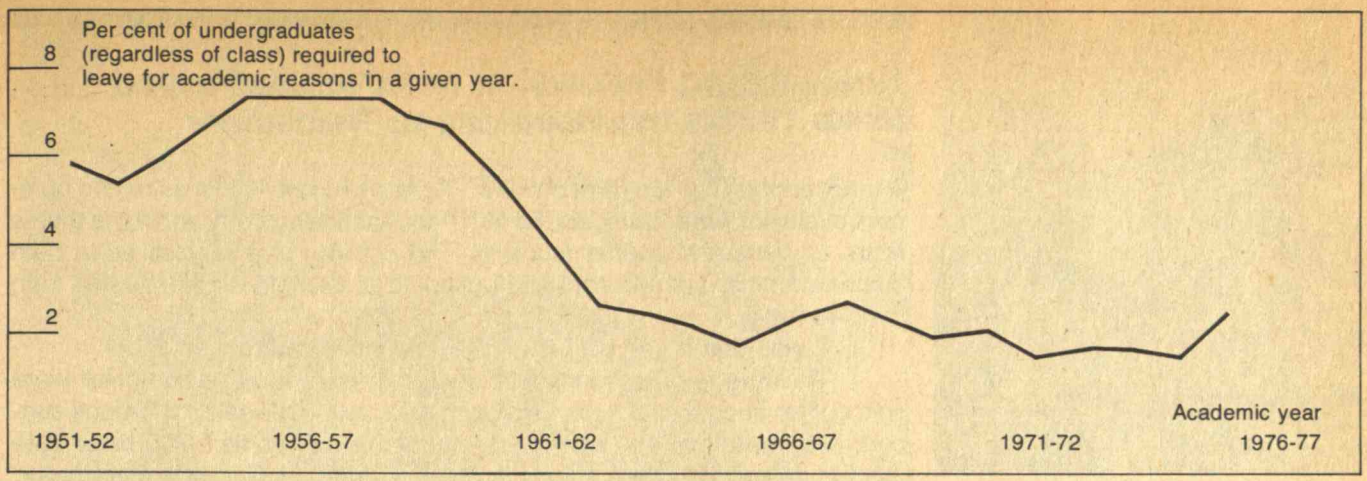
Dean Lobdell's dramatic warning was based in fact: even in the 1950s a freshman had about a 30-per-cent chance of being forced to leave the Institute — at least temporarily. Today only 6 per cent of a typical incoming freshman class will at some time be forced to drop out, and at least half of these disqualified students are later readmitted. The "flunk-out" rate has been steadily dropping — from 8 per cent per year in the 1950s to about 2 per cent per year today.

Some older grads are worried. They think of positive response to pressure as an important attribute of M.I.T. graduates, and they fear that the change in academic standards reflected in the changing "flunk-out" rate compromises the quality of an M.I.T. degree.

Not so, says Thomas J. Greytak, '62, Professor of Physics who is Chairman of the Faculty Committee on Academic Performance (C.A.P.). "Students provide their own personal pressure. The stress level is as high as it always was," he says, "and the over-all quality of the graduates has not decreased significantly."

Professor Greytak admits that the C.A.P.'s attitude on academic performance has been changing, and he credits that change to two developments:

☐ A significant change in attitude was instigated by the late Philip Franklin, Professor of Mathematics, when he was Chairman of the C.A.P. in 1961. Professor Franklin observed that, though all students admitted to M.I.T. were very bright, the Institute was for some reason failing to educate many of them. He voiced his concern in a faculty meeting, and thereafter the C.A.P. was asked to circulate data on the number of students given failing grades in various subjects.



Since 1950 there has been a sharp reduction in the percentage of undergraduates required to leave M.I.T. for academic reasons; 25 years ago an incoming freshman had about a 30-per-cent chance of being disqualified at some time during the undergraduate years, while now only 6 per cent of a typical freshman class will at some time be forced to leave. The fundamental difference, says Professor Thomas J. Greytak, '62, Chairman of the Committee on Academic Performance, is that the faculty now considers itself responsible for helping its students succeed at M.I.T. "The Committee is satisfied that students in academic difficulty are receiving fair and individualized consideration," he told the faculty this spring, "and that the level of performance below which we require a student to leave is set at about the right point."

☐ In the late 1960s there may have been a feeling among the faculty here, as in other colleges, of reluctance to be too tough, because disqualified students would be drafted.

There have been other changes at M.I.T. over the last few years, too: significant grade inflation, greater availability of and wider reliance on counseling services, and freshman pass/fail grading — all these reflecting a fundamental change in philosophy and priorities. Students in academic difficulty are first of all presumed to be qualified for M.I.T. — the same assumption that was made upon their admission to the Institute; and the emphasis is on understanding — and, if possible, resolving — the causes of poor performance.

Today the C.A.P.'s goal is to handle "each student's situation on an individual basis," says Professor Greytak, in marked contrast to the reliance on grades, cumulative averages, and other "widely publicized algorithms for determining probation or disqualification" which characterized an earlier day. When we were dealing with 8 per cent a year, "it's hard to imagine that they could receive today's personal attention," he says.

Of the undergraduates required to leave, 50 to 60 per cent are later readmitted; and of these, a few less than half typically continue to graduation.

There are two routes back: through the Dean of Student Affairs for those who voluntarily withdrew or who had personal problems that seemed likely to be solved; and through the C.A.P. for those with a history of poor academic performance.

The C.A.P. looks for two qualities in a student applying for readmission, says Professor Greytak: good grades at another college, or initiative and drive in some work experience. (An example of the latter is the student who began work at Massachusetts General Hospital as a secretary and ended up trouble shooting technical problems on sophisticated laboratory equipment.)

From its statistics on disqualifications and withdrawals, the C.A.P. reported three conclusions this spring:

☐ "M.I.T. has adopted a more lenient (and we feel realistic) view toward minimum academic achievement.

☐ "The students are presumably under less pressure from the threat of required withdrawal.

☐ "When we err, it is probably on the side of leniency. That is, there are probably more students who are allowed to continue who should be required to withdraw than there are students who are required to withdraw who should be allowed to continue."

In short, said the C.A.P., it is "satisfied that students in academic difficulty are receiving fair and individualized consideration . . . and that the level of performance below which we require a student to leave is set at about the right point."

Its major concern now is that students be treated uniformly and that the terminology reflect "an accurate picture of M.I.T.'s academic actions."

How Finding Fellowship in Adversity Helped Make 1977's the Reunions to Remember

A tardy northeaster took aim on New England on June 9, just as record numbers of alumni were taking aim on M.I.T. for Technology Day and more than a score of class and course reunions. The collision was precise as to both place and time, but rain-confined alumni took strength and fellowship from their adversity.

It was one of the best alumni weekends in recent memory.

Records fell like dominos. The 2,319 seats in Symphony Hall were sold out for Tech Night at the Pops by May 1, fully six weeks before the concert, and more than 400 alumni were turned away. Some 1,200 beds were used by alumni and their guests in Baker, Burton, McCormick, MacGregor, and New Houses between June 8 and 12, and a record crowd of 1,461 attended the Technology Day luncheon in Rockwell Cage; they came from as far as Korea, the Philippines, Hong Kong, Greece, Spain, Brazil, and Colombia; and classes from 1903 to 1977 were represented — the former by John A. Nolan, its Secretary, who had graduated from M.I.T. 74 years earlier.

By June 11, with rain coming almost horizontally on the northeast gale, the plans for three classes to sail to Georges Island in Boston Harbor for mid-day clambakes were cancelled; instead, clams, lobsters, corn, seaweed, and firewood were brought to Briggs Field, and more than 500 alumni celebrated the traditional New England feast in Rockwell Cage.

During five days from June 8 through 12, M.I.T.'s Food Services served 7,837 breakfasts, brunches, luncheons, box lunches, receptions, cocktail parties, dinners, and desserts/coffees for 53 different on-campus events in 16 different locations. At least 100 students — regular Food Service employees and temporaries — have been paid for between 35 and 70 hours of overtime each; "we were spread pretty thin," admits Salvatore Lauricella, Assistant Director of Food Services, but it all went like clockwork.

Arthur Fiedler and "The Explorers"

Special chemistry always works at Tech Night at the Pops. Arthur Fiedler, now 83 years old, takes obvious pleasure and even pride in wearing his red M.I.T. blazer, a gift of the Class of 1917, and nothing more surely proves to alumni that they're back in Boston than his swinging music and the festive atmosphere of Symphony Hall. This year's concert was enlivened by an exotic Concerto for Harp and Orchestra (Ann Hobson of the Boston Symphony Orchestra, soloist) by the contemporary Argentine composer Alberto E. Ginastera.

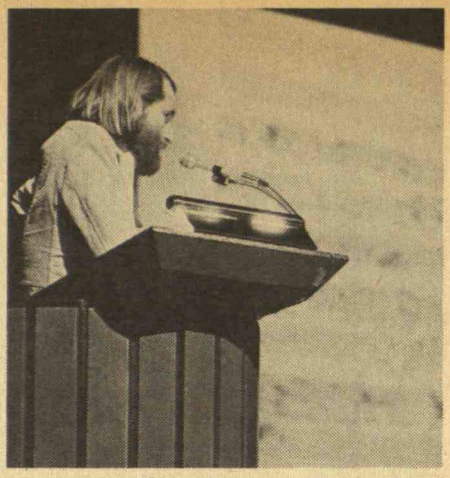
G. Edwin Hadley, '38, and his Technology Day Committee billed the Friday program as "The Explorers," having invited a panel of M.I.T.'s "promising young researchers" to report on industrial innovation, ocean and space science, industrial air pollution, and computer-based music. Here are brief summaries of their uniformly good, fast-paced presentations:

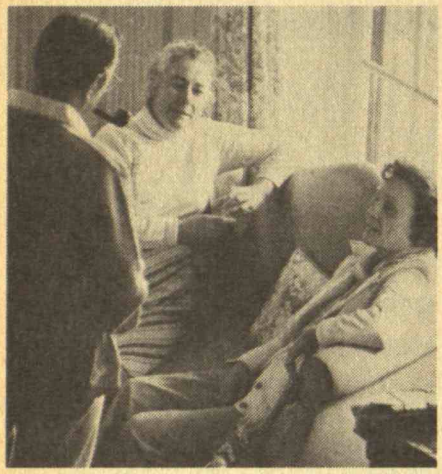
☐ Eric A. von Hippel, S.M. '68, Assistant Professor of Management: after intensive studies of several technology-based industries, Professor von Hippel is convinced that the wellspring of innovation is a user, not a manufacturer. A new product typically begins, he says, when someone devises something new which makes his own job easier or helps him do it better. The news travels to other potential users — and eventually a manufacturer is persuaded to tool up.

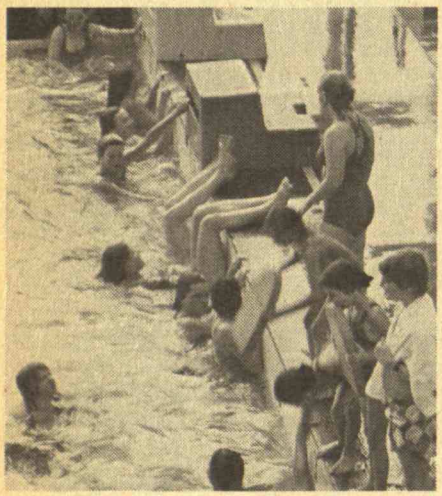
☐ Judith T. Kildow, Associate Professor of Ocean Policy: more than any other single issue, the question of exploiting marine resources — notably the manganese nodules on the sea floor — has deadlocked the Law of the Sea Conferences. The nodules — especially those in the central Pacific — are indeed rich in copper, nickel, and cobalt; but no one knows precisely how

Among those present (counterclockwise, from top opposite):
Paul E. Gray, '54, Chancellor.
Mrs. Karl T. Compton.
Joseph J. Martori, Director for Alumni Services.
Harold E. Edgerton, '27, with his 50th reunion classmates.
The beaver himself, the mascot delivering the Class of 1952 gift to President Wiesner.
John J. Nolan, '03, the oldest alumnus at Technology Day.
Edward O. Vetter, '42, retiring President of the Alumni Association (left), with his successor, Norman B. Leventhal, '38.
(Photos on these and following pages: Roger N. Goldstein, '74, Calvin Campbell, Marjorie Lyon, and John Mattill)

1
As the 25th reunion comes to an end, Arnold A. Kramer, '52, toasts the 30th.
2
M.I.T.'s first families at a luncheon tendered by the Class of 1917. Left to right: Dr. and Mrs. Julius A. Stratton, Howard W. Johnson, Mrs. James R. Killian, Jr., Mrs. Karl T. Compton, Dr. Jerome B. Wiesner, Mrs. Johnson, Mrs. Wiesner, and Dr. Killian.
3
Seven members of the Class of 1912 pose with their guests at their 65th reunion.
4
The 40-year Class of 1937 gave President Wiesner an oversize check to symbolize its oversize reunion gift.
5
A standing ovation for Arthur Fiedler — he must be M.I.T.'s favorite Bostonian — at Tech Night at the Pops.







large the resource really is, and Professor Kildow is among the skeptics: there may be as few as 30 good mine sites (areas capable of yielding 3 million tons of nodules annually for 20 years) in the Pacific, and the amounts of copper, nickel, and cobalt to be obtained are probably less than we now count in land-based reserves of these same three minerals.

(In the ensuing discussion, John E. Flipse, '42, President of Deep Sea Ventures, Inc., took a more optimistic view: what may not look like a mine today will seem vastly more interesting in the future, he said, as land-based resources are depleted. Mr. Flipse's firm is leading an effort to exploit the Pacific nodules, and to prove the liveliness of the issue Mr. Flipse provided real-life nodules, each in its own plastic bag, for every Technology Day visitor.)

☐ John S. Lewis, Associate Professor of Chemistry and Geochemistry: the age of exploration originated in the breakdown of the medieval Catholic Church, when the ravages of the black plague forced Western Europeans to question the nature of their world. Our legacy is the space age — and the notion that mankind can extend its own known limits, by applying the correct tool to the proper materials in the right sequence. Too, the age of exploration bestowed the notion of the uninvolved observer, a Newtonian assumption that man can put nature to the question in an inquisition that presupposes the separation of the observer and the observed. Einstein believed in relativity — observation has as much to do with the looker as with the lookee — and now we believe the same, as subscribers to a "new humanism" which must now be extended to our technology.

☐ James R. Melcher, Ph.D. '62, Professor of Electrical Engineering: as we use our last drops of oil, coal — dirty as it is — becomes increasingly seductive. While coal won't win any beauty contests — it blackens air, its submicron particles lodge in lungs; its gases poison — it is plentiful. The best method of cleaning up sooty coal smoke has been with electrostatic precipitators; if you don't know how they work, ask Dr. Melcher to demonstrate with his plexiglass smokestacks, electrostats, smoke, and graduate students to coordinate the whole show. Electrostatic precipitators scrub minute particles of soot from smoke before it leaves the smokestack through the use of an electric field: the particles, charged by electrons, gather at the walls and fall back into the stack. Even better, Dr. Melcher demonstrated, is to run smoke through a "sandbox" with an electric field, called an electrofluidized bed. Sand can be cleaned, the particles captured, and, he says, the whole process is more economical than most in use right now.

☐ Barry L. Vercoe, Associate Professor of Music: computers are now available to give musicians the same new, rich creative modes that the technologies have given visual artists. Professor Vercoe's work in the M.I.T. Experimental Music Studio, for example, now allows composers to draw musical scores on a display screen and hear the resulting sounds as synthesized by the computer.

The Technology Day luncheon was enlivened by a "beaver," a "Loch

Ness monster," an oversize Polaroid camera, and the announcement of reunion gifts totaling more than $2.7 million (*see page A14*). And by Friday evening, as Technology Day adjourned, more than 1,000 alumni attended a record 12 departmental open houses and parties.

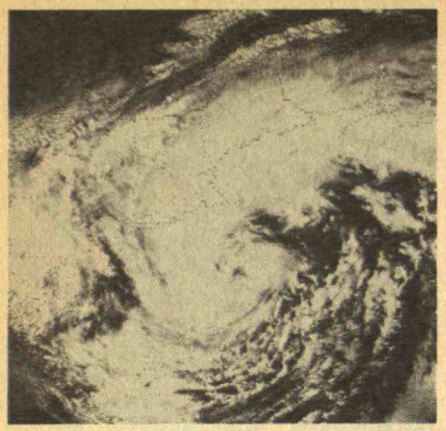
A Rich Sampling of Hospitality

Thirteen classes — every fifth year from 1912 to 1972 — were on the campus for reunions, and they sampled most of the hospitality which M.I.T. can offer — Historical Collections, where there were seven receptions and meals (including two dinner-dances) served amid M.I.T.'s nostalgia-generating memorabilia; the Twenty Chimneys; the President's House, the Faculty Club; the Pierce Boat House; and dining halls in Baker, Burton, McCormick, MacGregor and New Houses.

Off-campus reunion features were intriguing, too. The Classes of 1917 and 1927 scheduled portions of their reunions at Chatham Bars Inn and the Wianno Club on Cape Cod; the trip to Georges Island for a clambake on Saturday gave way to a windblown tour of Boston Harbor aboard the *Provincetown,* whose scheduled trip to the Cape was cancelled by the weather. There was a post-Pops party for the Class of 1952 in the showy Upper Rotunda of the restored Quincy Market, across the street from Durgin Park. Other destinations included the Chateau de Ville in Framingham; the Hyatt Regency in Cambridge, the Copley Plaza in Boston, Heritage Plantation in Sandwich, the Essex County Club, the Rivers Country Day School, and the Wellesley campus.

Letters written to Joseph J. Martori, Director of Alumni Services, were warmly complimentary about everything but the weather: "smash hit," "very tired," "best ever," "slightly overfed." And George J. Schwartz, '42, Chairman of his Class' 35th Reunion which was flooded out of its clambake on June 11, now says he is "flooded with rave notices." — *J.M.*

People and places (counterclockwise, from top left opposite):
Edward O. Vetter, '42, presents Honorary Membership in the Alumni Association to Mrs. Priscilla Gray, the wife of M.I.T.'s Chancellor.
Members of the Class of 1937 at the Essex County Club.
The children's program at the Alumni Pool.
Harold W. Fisher and Jack B. Peters with the Class of 1927 at the President's House.
Memories at Historical Collections.
Professor Barry L. Vercoe on music by computer.
Members of the Class of 1932 at Heritage Plantation.
(Photos: Roger N. Goldstein, '74, Calvin Campbell, Marjorie Lyon, and William A. Newman)



Henry G. Steinbrenner, '27 (shown here with Mrs. Steinbrenner at the Technology Day luncheon) has been a sports fan from his undergraduate days, when he was a champion runner. Now he's given funds for a new Steinbrenner Stadium.

Forecast — Fair; Weather — Foul

When anxious planners began listening for weather forecasts for Technology Day and the reunions on June 8, the word was good: showers Thursday night from a fast-moving wave then in the midwest; after that, fair and warmer on June 10, 11, and 12.

But 24 hours later forecasters were beginning what is called in the trade an "agonizing reappraisal," says Frederick Sanders, Sc.D. '54, Professor of Meteorology at M.I.T. The little wave was intensifying as it crossed the Appalachians and would be a strong storm by the time it arrived off New England. But it would stay at sea, and the forecasts now mentioned clouds, wind, and perhaps some drizzle.

The picture above, as received at M.I.T. from the N.O.A.A. geostationary weather satellite, shows the truth of the matter: a swirling vortex of moisture engulfing Cape Cod and approaching Boston by Friday afternoon and delivering an inch of rain or more by Saturday afternoon — dampening the clothes if not the spirits of 1,200 reunion-goers at M.I.T.

A "metastable situation" typical of New England in the spring, says Professor Sanders. Under such conditions, he says, "forecasting the weather for more than 24 hours is a little like trying to think 40 moves ahead in chess."

The Class of 1952 Survey: A Snapshot of Success

Twenty-five years after graduating from M.I.T., at least 15 members of the Class of 1952 are millionaires (net worth $1 million or more); more than 90 per cent own their own homes, and of those homes at least a third have market values of $100,000 or more; 10 per cent earn $75,000 or more a year; and 49 per cent own two cars, 26 per cent three cars.

Half the members of the class say they have achieved "much more" or "more" than they expected, and 30 per cent more say their goals have been reached "on schedule."

Little wonder, then, that 75 per cent of the Class of 1952 say they would come to M.I.T. if they had it to do over again, and 69 per cent would encourage their children to come to the Institute now.

These results are from 247 members of the Class of 1952 surveyed just prior to the 25th reunion. It's a snapshot of success in traditional American colors, with few surprises in the data.

Of the respondents, 23 per cent are in research and development, 33 per cent are in management, and 32 per cent own their own businesses.

They're a mobile bunch: 17 per cent have made five or more moves since graduating, only 19 per cent are with the companies in which they were first employed. And they travel (on business) a lot: 21 per cent are away three to five days a month, another 43 per cent one or two days a month.

Politics? Conservative. Sixty per cent say they voted for Gerald Ford, only 35 per cent for Jimmy Carter.

Personals: 7 per cent are divorced, and another 7 per cent have been divorced and now are remarried; 82 per cent are married, only 2 per cent single. Five per cent already have grandchildren.

Alumni Giving as a Measure of Loyalty to Alma Mater

President Jerome B. Wiesner called it an "extraordinary display of support for M.I.T. . . . special encouragement," he said, to those who are working so hard to trim budgets and increase giving to the Institute's $225 million Leadership Campaign.

This was his response to announcements of more than $8 million in alumni giving to M.I.T. made during the annual luncheon on Technology Day, June 10. In fairness, some of the $8 million was counted twice, some of it is giving which is conditional on future events, and some of it has been counted in Alumni Fund totals for prior years.

But the generosity, warmth, and supportiveness of the occasion — made certain by the amateur theatrics which accompanied the several announcements — could not be doubted.

"Beaver, Beaver" was the hit song of the 1949 Tech Show, and its revival by the Class of 1952 was the hit of the Technology Day Luncheon in Rockwell Cage. As the time came for Stanley H. Sydney, '52, to make his report as Reunion Gift Chairman for the Class, the strains of this old favorite filled the hall, and an outsize beaver, brandishing an equally outsize slide rule, danced through the tables and up to the rostrum. Using the slide rule, Mr. Sydney (with help from the beaver) exposed the figures for the total of the reunion gift: $1,305,225.52; that represented the total giving of the Class in the five years immediately preceding.

Next came G. Richard Young, '37, who called forth a team of classmates with an oversize Polaroid camera — William J. McCune, Jr., President of Polaroid Corp., is a member of the Class. They took a picture of President Wiesner, but the image turned out to be an oversize check for a reunion gift of $467,327.

Finally, the notes of a bagpipe, leading a "Loch Ness monster" which in turn escorted two members of the Class of 1927 carrying a treasure chest. The presentation honored

Harold E. ("Poppa Flash") Edgerton, Sc.D. '31, who received his first M.I.T. degree (S.M.) in 1927. There was some banter about how the Class of 1927 dissented from adopting the "monster" as its mascot for fear of offending the beaver and some talk about cross-breeding Nessie the "monster" with a beaver ("a beaver is quite capable of almost anything") to create a "beaverness"; and when that source of humor began to run dry Raymond F. Hibbert and Harold W. Fisher, Class President and Reunion Gift Chairman, respectively, made their presentation to President Wiesner: moneybags representing a reunion gift of $987,620. In addition, said Mr. Fisher, 56 members of the Class have indicated that they will give an estimated $1.39 million in bequests.

More good news for President Wiesner: the 1977 Alumni Fund stood at a record $4,277,028 on June 10, said Edward O. Vetter, '42, President of the Alumni Association, and the total would be "significantly higher" by the end of the Fund year, he said.

Presenting Billard Awards, Honorary Memberships, and a New Gavel

Presentations and kudos are the order of the day on Technology Day; this year there were five at the annual luncheon:

☐ To **George H. Dummer,** Director of the Office of Sponsored Programs, a $500 Gordon Y. Billard ('24) Award from President Jerome B. Wiesner.

☐ To **Priscilla K. Gray,** wife of Chancellor Paul E. Gray, '54, Honorary Membership in the M.I.T. Alumni Association from Edward O. Vetter, '42, President of the Association.

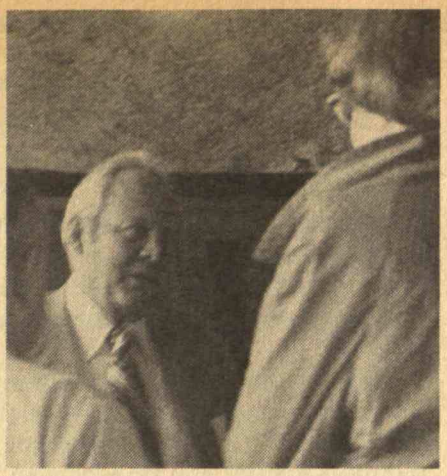
☐ To **Norman B. Leventhal,** '38, a gavel symbolic of his new office as President (effective July 1) of the Alumni Association from his predecessor, Mr. Vetter.

☐ To **Mary J. Manning,** who retired last month after 24 years as Executive Secretary and Staff Assistant in the Educational Council Office, Honorary Membership in the Alumni Association from Mr. Vetter.

☐ To **Mary P. Rowe,** Special Assistant to the President and Chancellor for Women and Work, a $500 Billard Award from President Wiesner.

The Billard Awards, established by Mr. Billard in memory of his mother, are given to members of the faculty or staff for "special service of outstanding merit" performed for M.I.T. President Wiesner's tributes to this year's recipients were warm and generous: Mr. Dummer, he said, has given "monumental devotion" to his assignment in research administration. "He has kept M.I.T. in the position of innovator on a national scale in adjusting the terms and conditions of sponsored research" to provide both maximum protection for the Institute and maximum benefits to sponsors. President Wiesner described Dr. Rowe as "a woman for all seasons and reasons, an incredible source of hope and encouragement, . . . one of the finest human beings who has graced this campus."

Before Technology Day there were only 23 Honorary Members of the Alumni Association — "people whose service and devotion to M.I.T. have been extraordinary," said Mr. Vetter. In presenting Mrs. Gray, Mr. Vetter said her "friendship and support . . . have earned for you the love and respect of thousands of alumni." And to Ms. Manning he said, "Alumni across the country have come to know and rely on you for help in every aspect of Educational Council activity . . . To make you a part of the family is only confirming something that has been a *de facto* reality for many years."



The manganese nodules are the bete noir of the stalled Law of the Sea Conference, said Professor Judith Kildow at Technology Day; and to show what she was talking about, John E. Flipse, '42, President of Deep Sea Ventures, Inc., brought along enough souvenir nodules for the whole audience. He's optimistic, he said (left); use of the nodules is only a question of time and diminishing terrestrial resources, despite today's volatile political and uncertain legal environment.

A Stadium from Henry Steinbrenner to Celebrate a Life-Long Interest in Track

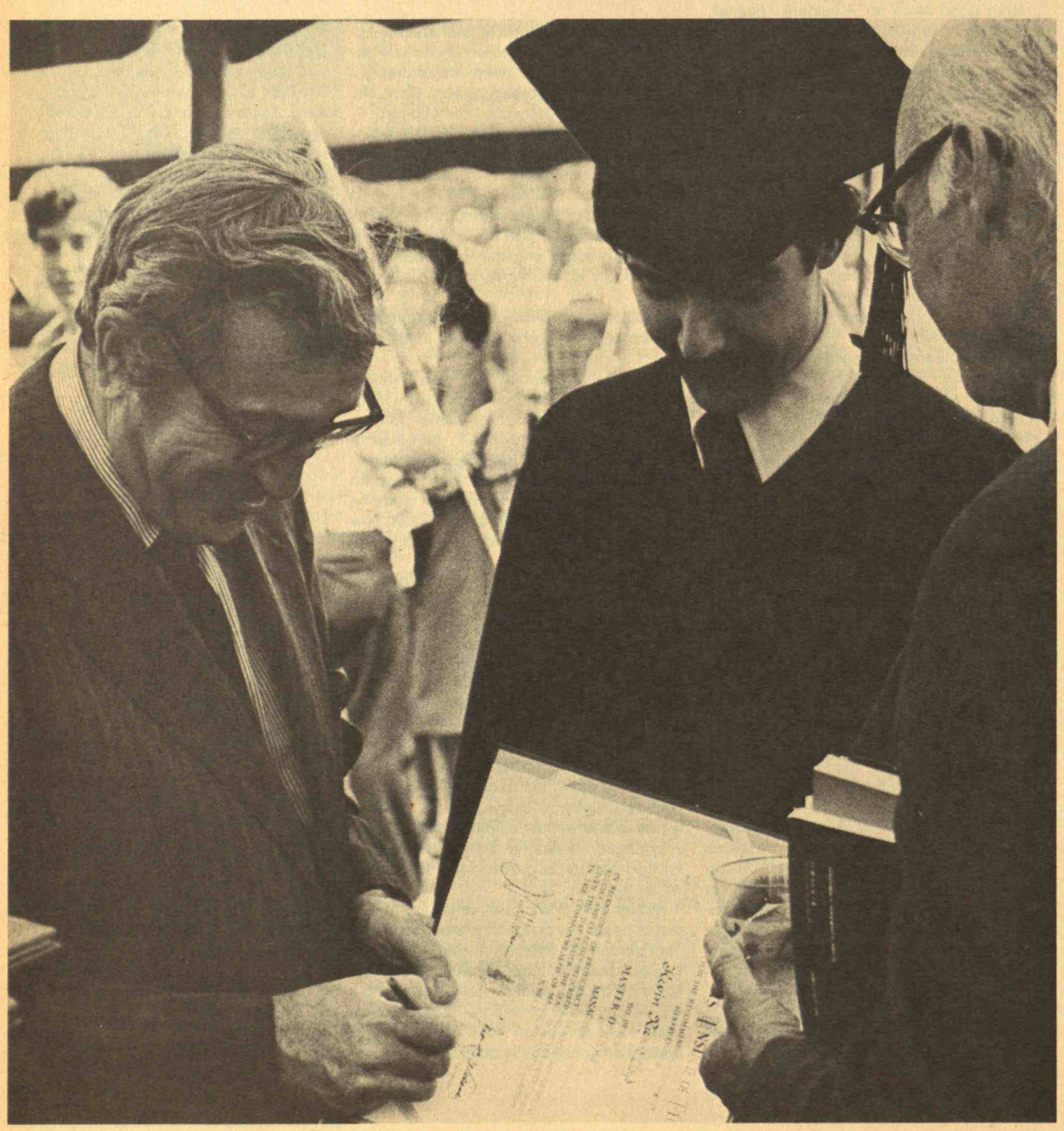
Henry G. Steinbrenner, '27, who's widely regarded as the dean of Great Lakes shipping after a career in the Kinsman Marine Transit Co., is the only M.I.T. man ever to have won an outdoor national track championship. That was in his senior year, when he was Captain of the varsity track team: he won the national collegiate 220-yard low hurdles in the then-record time of 23.9 seconds.

In June, on the occasion of his 50th Reunion, Mr. Steinbrenner came back to M.I.T. to make possible construction of a new outdoor track, field, and game facility which will be named in his honor.

The Steinbrenner Stadium, west of Rockwell Cage on Briggs Field, will have a 400-meter running track as well as facilities for the steeplechase and all field events except the hammerthrow. There will be a game field within the track oval and permanent seating for 400 spectators at soccer, lacrosse and women's field hockey games. A synthetic, all-weather surface will be used for the track and field events with natural turf within the oval.

Nearly 100 of Mr. Steinbrenner's classmates heard the plans announced by President Jerome B. Wiesner at the Technology Day luncheon on June 10. Since then construction on the stadium has begun, and it will be complete for use in the fall. Its first track meet will be in April, 1978, when a dedication ceremony is planned.

The traditional scenes of Commencement came alive for a new class on June 6. Below, President Jerome B. Wiesner seems bemused as he signs his name a second time (at the post-Graduation reception) on Kevin R. Lloyd's master's degree; Professor E. Cary Brown, Head of the Department of Economics, is watching. (Photos: Dek S. Lee, '79, from Technique*)*



Commencement: A Family Celebration Mixing Equal Portions of Pomp and Exuberance

Commencement evokes emotions of all kinds — joy, relief, and release for the students; pride (and perhaps relief) for the parents; integration and rededication — and relief — for the faculty. At M.I.T. on June 6 all these sentiments found expression in the traditional formality of the Graduation Exercises. The celebration, at once formal, warm, joyous, sometimes effervescent, was never quite pompous.

President Jerome B. Wiesner presented a total of 1,492 degrees to 1,323 graduate and undergraduate students — 751 bachelor's degrees and 741 graduate degrees, including 143 doctorates.

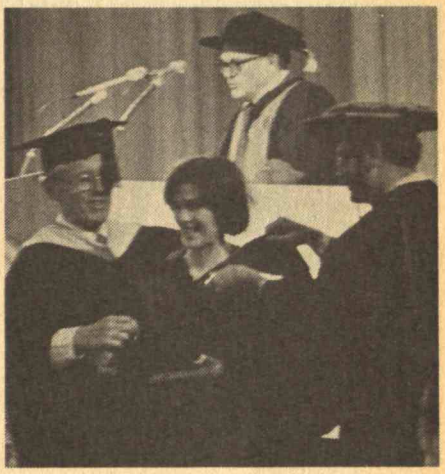
A quick calculation suggests that each student may have invested on average as much as $25,000 (tuition and living expenses) in those degrees — reason enough for the pride which every parent felt on this warm, sunny morning. Hence President Wiesner's opening tribute to families and friends: "There is no adequate way to express appreciation for what you have done to help make this day possible," he said.

Dr. Wiesner summarized his own view of the importance of the occasion and of the experience which graduates carry away from the Institute with their diplomas: "No matter how deeply you are involved in solving some immediate problem, the events and issues of the society at large will impinge upon you," Dr. Wiesner said, with the result that graduates will be called on to help society balance the benefits and risks inherent in the decisions that must be made in the future.

"In a world so dependent as ours upon science and technology, in which decisions are made by majority choice, . . . men and women educated as you are in the special disciplines of science, technology, and the humanities — you who are multi-literate in this special sense — can form a vital bridge . . . from which will emerge an understanding and shared vision of what our nation can become."

The students summed up their emotions on this special day very differently. When his turn came to receive his master's degree, Andrew J. Rubel, '75 — he's been an outspoken unicycle booster throughout his six years at the Institute — withdrew his unicycle from under his robes and pedaled himself across the stage. The audience was delighted.

Cheers followed for the undergraduate who, upon receiving his degree, tossed a handful of confetti to shower down on President Wiesner. Another graduate conjured a bottle of champagne from under his robes, popped the cork into the audience, and began enjoying the bubbly. Master's degree graduates from the Sloan School of Management demonstrated their enthusiasm by cheering each other as Dean William F. Pounds called their names.



"No Excuses Will Be Accepted . . ."

No complications interfered with the M.I.T. tradition that every M.I.T. graduate receives his or her own diploma personally from the hand of the President. That this happens for over 1,300 candidates every year as they parade across the stage is the result of some exquisite planning — and some threatening language.

In May every candidate receives instructions from the Registrar: "A diploma will *not* be given at the Graduation Exercises unless you are in the proper place for the assembling of the procession at the du Pont Gymnasium by 10 a.m. on Monday, June 6 . . . Ample time should be allowed in case of delays. No excuses will be accepted for being late . . . Candidates who arrive late will be excluded from the procession."

On the morning of Commencement an aide is assigned to each of 30

Celebrating before Commencement, the Class of 1977 organized events reminiscent of an old-fashioned "senior week" — a formal dance for classmates and guests and a clambake in honor of parents. (Photos: Dek S. Lee, '79, from Technique)

(right) A toast by the three officers of the new Class of 1977: (left to right) Douglas J. McLeod, Secretary-Treasurer; David A. Dobos, President; and B. Robert Ruotolo, Vice President.

stations in the Gymnasium; his principal job is "to verify that the graduates (assigned to each station) are in the proper station by 10 a.m. . . . Stragglers will be permitted to enter the station lines in the proper places up to 10:10 a.m., at which time the aides will make a final check of the graduates present. This check of those present shall be completed by 10:15 a.m.; . . . no candidate can then enter the line under any circumstances."

From then on there are only two important instructions for the graduates: "Each candidate shall march to the red stop line located eight feet from the diploma rack and advance as soon as his/her name is called. *Do not shake* President Wiesner's hand . . . Tassels of the candidates for all degrees should be worn on the right front side before, and changed to the left front side after, receiving diplomas."

"The Corporation and Faculty Are Now Declared Convened . . ."

If it sounds like clockwork, it is. A timetable, circulated in advance to the principals, calls for the academic procession to enter the Rockwell Cage, led by the graduates, at 10:30. By 10:43 the procession of students has advanced so that the Chief Marshal, Edward O. Vetter, '42, President of the Alumni Association, arrives in the cage. At 10:50 Mr. Vetter ascends the stage and places the mace — the symbol of the Corporation's authority to conduct the exercises — in its holder. By 10:53 the Brass Choir conducted by John D. Corley, Jr., Director of the M.I.T. Concert Band, completes playing the national anthem, and Howard W. Johnson, Chairman of the Corporation, steps to the rostrum: "The Corporation and the faculty of the Massachusetts Institute of Technology are now declared convened . . ."

President Wiesner is not above the schedule: he is given ten minutes for his address to the graduates, starting at 10:56, and by 12:30 Mr. Johnson announces that "the 111th Graduation Exercises of the Massachusetts Institute of Technology are now concluded."

A Family Affair

The Class of 1977 included at least nine children of members of the M.I.T. faculty and staff and more than 30 alumni sons and daughters (*see right*). Christopher R. Perley, whose S.B. was in chemical engineering, became the third generation in his family to hold an M.I.T. degree; his father is Richmond Perley, '49, and his grandfather the late George K. Perley, '14. And Jeffrey A. Babb, whose S.B. was in mechanical engineering, has a grandfather — Maynard A. Babb, '28, and two uncles — David D. Babb, '49 and Eugene N. Babb, '51 — who are alumni. — J.M.

Edward O. Vetter, '42, preparing to serve as Chief Marshal of the Graduation Exercises, receives some advice from a colleague on the M.I.T. Corporation, Breene M. Kerr, '51.

30 Chips off the Old Block

Commencement 1977 was a family affair. Among the 751 students who received bachelor's degrees on June 6 there were at least 30 sons and daughters of alumni:

Anne L. Averbach (mathematics), daughter of Benjamin H. Averbach, Sc.D. '47.

Jeffrey A. Babb (mechanical engineering), grandson of Maynard A. Babb,' 28.

Paul M. Bangser (civil engineering), son of William Bangser, Jr., '48.

Louis Bernstein (civil engineering), grandson of M. Jack Bernstein, '34.

Margaret L. Brandeau (mathematics), daughter of Edward P. Brandeau, '47.

Roselie A. Bright (life sciences), daughter of Charles D. Bright, '48.

Sterling G. Brisbin, Jr. (civil engineering), son of Sterling G. Brisbin, '50.

Bruce S. Buchanan (electrical engineering), son of Harry W. Buchanan, S.M. '56.

Thomas C. Donnelly (economics), son of Thomas J. Donnelly, '46.

Frederic W. Faller (earth and planetary sciences), son of Alan J. Faller, '51.

George R. Fryling (mathematics), son of George P. Fryling II, S.M. '64.

Eliot W. Goldstein (art and design), son of Stanley J. Goldstein, '46.

Thomas C. Gooch (civil engineering and humanities and science), son of Robert S. Gooch, '51.

Brian T. Harrington (civil engineering), son of John V. Harrington, Sc.D. '58.

Robert P. Humphrey (civil engineering), son of Harvey J. Humphrey, '49.

Wendy C. Irving (art and design), daughter of the late Wendall D. Irving, '49.

David F. McKinley (life sciences), son of Francis J. McKinley, '44.

Guy J. Nordenson (civil engineering), son of the late Lars Nordenson, '41.

Christopher R. Perley (chemical engineering), son of Richmond Perley S.B., S.M. '49, and grandson of the late George K. Perley, '14.

Roger F. Powell (computer science and engineering), son of Richard F. Powell, '52.

William R. Rapoport (electrical engineering), son of William J. Rapoport, '46.

Donald E. Rediker (chemistry and biology), son of Robert H. Rediker, '47.

Winifred Mary Kim Roddis (civil engineering), daughter of Louis H. Roddis, S.M. '44.

Mary C. Shaeffer (chemical engineering), daughter of Ruth Gilbert Shaeffer, Ph.D. '46.

Loren Shure (physics), daughter of Kalman Shure, Ph.D. '51.

Arlie G. Sterling III (economics), son of Arlie G. Sterling, Jr., '48.

Kenneth C. Sun (aeronautics and astronautics), grandson of Ming Shin Pin, '20.

Louis L. Touton (mechanical engineering and electrical engineering), son of the late Louis Touton, '37.

Steven J. Weissburg (mechanical engineering), son of James Weissburg, '52.

Ian R. Wilson (economics), grandson of David H. Wilson, '29.

Wiesner to the Class of 1977: Embrace the Problems of Society; There Cannot Be a No-Risk World

The following is the text of President Jerome B. Wiesner's principal remarks to members of the Class of 1977 and their guests at the Institute's Graduation Exercises on June 6, 1977:

During the four years that the Class of '77 has been here we have shared many experiences. While you were suffering through problem sets, quizzes, Fourrier transforms, Registrar's forms, and tuition hikes, and while M.I.T. was navigating through financial shoals, all of us were nonetheless aware of major events occurring outside the Institute. These were the years of Watergate, the Bicentennial celebration, the first public recognition of impending energy shortages, growing struggles for personal freedom in many countries around the world (and growing repression, too), and most recently a national Presidential campaign and election in which, despite sharp differences, we have chosen leaders in accordance with the collective values of the people.

On the campus, we debated issues that reflected some of these outside concerns; among, them, for example, were educational programs sponsored by foreign governments. We have also been close-up witnesses to one of modern history's few attempts to limit scientific inquiry, the recent DNA controversy. We have had lively discussions over such academic issues as the humanities requirements, pass-fail, sculpture on the campus, the Writing Program — and newspapers.

You took all these events, local and national, seriously and engaged vigorously in the discussion and the sorting out of the hopes and frustrations which have taken place in our society during these four years. You saw — perhaps for the first time — how precious and delicate a democratic society really is.

The seeds planted by all of these events are with us as a growing part of the nation's view of itself and its future. Each, in its own way, represents a challenge to our ability to understand and to set, or reset, national, local, and personal priorities.

Common Good vs. Individual Freedom

This morning I want to use these events to highlight four points.

First, we have seen that no matter how deeply you are involved in solving some immediate problem, events and issues in the society at large will inevitably impinge on you. At M.I.T. you have demonstrated a serious concern for your non-academic as well as academic environment and have learned, I believe, that your actions *can* influence events enough to make the effort worthwhile. The college generation of the 1960s left us with the now-classical slogan, "If you're not part of the solution, you're part of the problem." This was meant to debunk the ostrich theory that if one ignores a problem long enough it will simply go away. That college generation found that events important to them had to be dealt with head on, couldn't be ignored. Thus they played a major role in shaping the nation's views on a number of issues, chief among them the Vietnam War, and many of them are young leaders of today. You, the Class of '77, have demonstrated that you are equally determined to help shape the world in which you live.

My second point is a related but broader issue — namely, how our nation can learn to deal collectively with large national issues while, at the same time, retaining a fundamental respect for the hopes, feelings, and freedom-to-choose of the individual. This is the central question of our time; it is fundamental to our way of life. It was recently said by an M.I.T. faculty member, most poignantly, that social policy — no matter how benign — can feel to an individual like a bulldozer in one's living room. If you're directing the path of that bulldozer (and many of you will be in such positions), clearly you will want to be aware of its power. Individual rights tend to fall before the common good. Somehow we need to recognize that preservation of freedom and individuality, in the face of increasing societal restrictions, is a most essential common cause.

Balancing Benefits and Risks

My third point can be stated rather simply. Most of our vital societal goals are in competition with one another, yet they must be reconciled. For example, complexity and size demand increasing control and regulation, a social need which is clearly in conflict with individual freedom and initiative which have been our traditional sources of strength and greatness. The great drive for social and economic equity is not without its financial costs and political strains, requiring resources and attention that might be devoted to other, equally important or desirable goals. The need to protect and restore the environment for future generations limits what we can build or use today, and yet we are accustomed to take almost as a right the freedom to consume as we choose. Past and recent experiences with the unexpected side effects of technology are causing people to be much more cautious about the introduction of new technologies, even though such technologies will be needed if we are to strike a viable balance between man and nature in the future. Many more examples could be listed. The main thing to realize is that it isn't a question of rights and wrongs but rather of balancing conflicting goals, so that society as a whole can continue to develop effectively on many fronts with minimum discomfort to all.

The adjudication of conflicting goals is made more difficult when the choices involve not just preferences but risks. When the hazards people faced were mostly of the kind we called "acts of God," whether in the form of epidemics or natural disasters or even wars, they were faced resignedly and stoically. What else could one do? Today we face an additional set of risks — those associated with man-made technology. Unlike natural disasters, the probability of man-made risks can usually be adjusted. Unfortunately, the cost of making the risks very small is apt to be very large, and finding an appropriate balance is not just a technical question or even an analytical one but a question of value — which risks are worth what costs?

Using the energy question as a case in point, we can see in it the conflicting goals of protecting health or the environment, or avoiding accidents, and still assuring energy supplies for the decades ahead. At the moment there is opposition to nuclear power plants, strip mining of coal, burning

coal, drilling for oil off the East and West Coasts, oil tankers, the construction of pipelines to carry natural gas or of liquefied natural gas facilities to bring in gas by ship, and mining of tar sands and oil shale. Each of these choices does pose some real problems; some pose actual, though small, risks. Yet in the end to do nothing and thus fail to provide for the nation's future energy needs would pose the greatest threat of all for our democratic society.

The Risks of Fear vs. Risks of Knowledge

The balancing of benefits and risks has recently led to concern about a specific area of fundamental research which new technology has made possible. We in Cambridge have had a ringside seat in the extremely interesting debate over DNA research. It appeared for a time that such research might be totally prohibited here — to me, a most disturbing prospect. The challenge has now moved to the national level, where legislation is being considered for the supervision of DNA research. Currently, scientists are trying to ensure that appropriate monitoring does not turn into precedent-making restrictions and regulations.

I am certain that in years to come we will frequently hear proposals to restrict research in one or another field of science; and you can be almost certain that they will be the most interesting fields, for in them will be found the widest range of new opportunities — and worries. In my view, to carry out such restrictive actions would stifle human progress. The long-term costs would be very high, because a civilization which limits its inquiry for fear that what it learns might be misused would soon suffocate both its intellectual life and its social development. On the other hand, a civilization which doesn't learn how to be sensitive, selective, and timely in the deployment of new technology is condemned to cope with major disruptions either from technology's belated deployment or its absence.

At any given moment, the incommensurate trade-offs between environment, intellectual vitality, health, aesthetics, energy, risks, and economic welfare can be made only through informed public debate. Since there are conflicting viewpoints in the society, the final result will rarely satisfy anyone completely. But the better informed the debate, the more likely the result will approximate a true balancing of interests.

Thus to my fourth, and final point: it is essential to improve the quality of the public debate over the socio-technical issues before us.

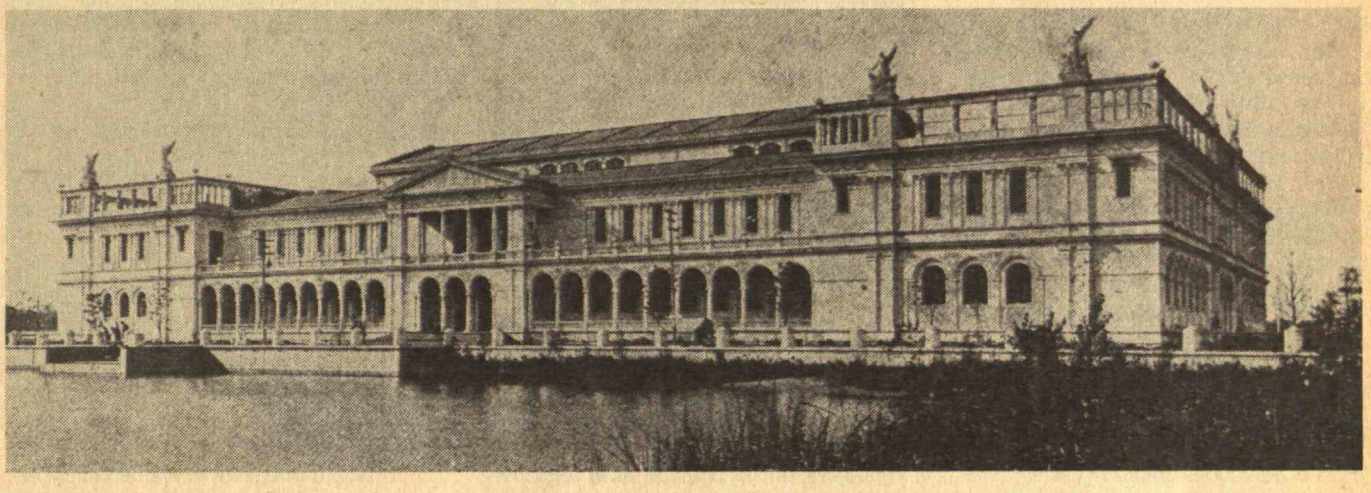
Here your help will be most valued. Many of these conflicts exist because the various interest groups are not able to communicate. We know from communications theory that shared symbols are the only basis for any communication process. But increasing differences in educational experience and life style among the various professional and working groups in the country have minimized that common heritage. Common words conjure up quite different images, and understanding is hard to achieve. In a world so dependent as ours upon science and technology, in which decisions are made by majority choice, the lack of an adequate shared language will make rational choice extremely difficult. Men and women educated as you are in the special disciplines of science, technology, and the humanities — you who are multi-literate in this special sense — can form a vital bridge between people of differing backgrounds and interests.

I am confident that if we all engage these issues seriously there will emerge an understanding and shared vision of what our nation can become.

Up in the air in the spring. As Commencement approaches, M.I.T. puts its best foot forward: curtains are hung in Rockwell Cage and the four-story windows in the Rogers Lobby are cleaned of a long winter's grime. (Photos: Calvin Campbell)

Under the Domes

The world of women's rights, circa 1893. The Women's Building at the World's Columbian Exposition in Chicago was designed by Sophia Hayden, the first woman to graduate (1890) from M.I.T.'s four-year course in architecture. The picture was in the exhibition of "Women in American Architecture" this spring.



The Achievements of Women in Architecture

"Women in American Architecture: A Historical and Contemporary Perspective," plans, photographs, and statements on the work of women in architecture, opened at M.I.T.'s Hayden Gallery early in May, following a three-month showing at the Brooklyn Museum in New York.

Susanna Torre, coordinator of the exhibit and editor of the book of the same title, was there to christen the exhibition, which had been expanded since its New York showing by several contributions from M.I.T.'s Historical Collections.

After two years of search to find and document the lives of the women who have made contributions to architecture in the U.S. over the last 100 years, Ms. Torre calls the effort "frustrating." Women's contributions are "modest, but interesting," she says, but their documentation cannot be seen as a history of architecture. Her presentation rather chronicles the place of professional women in the social history of the last 100 years.

Despite efforts to avoid stereotype, the theme that dominates is domesticity. The exhibit contains the work of Catherine Beecher, the "domestic technocrat" who in 1869 designed homes geared to aid women in their work and, it must be noted, to develop "Christian womanhood." Pages of the *Los Angeles Home Magazine* from 1957 are shown; an article titled "Good Ideas by Women Designers" implies an air of surprise, says Ms. Torre. But the ideas are limited to new ways to arrange kitchen cupboards.

There are reasons for women's minor place in the architectural profession, says Ms. Torre. The "male clubbiness" of the profession works to exclude women; the professionals come mainly from the upper classes; women in the field have been more dedicated to the doing of the job than to lobbying for an equal place and thus have been content to work as assistants without recognition. As the exhibit makes clear, some women who may have achieved success have failed rather than defied convention. Among these is Sophia Hayden, '90, who was the first woman graduate of M.I.T.'s School of Architecture. Her design for the Woman's Building won acclaim, and the building was erected at the World's Columbian Exposition in Chicago in 1893. Her design was judged at the time to be as good as any architecture school graduate with two years' experience. Under pressure, she developed "brain fever" and was unable to attend the dedication of her building. She never again attempted to design — a fitting example, some said, of how women were ill equipped to work in the field.

Ms. Torre herself contributes to the notion that feminine attributes belong exclusively to women. In the section of the exhibit labeled "Spatial Symbolism," she says that women must be, and therefore are, more "flexible" and more "sympathetic" — characteristics which replicate themselves in architectural design. Some may disagree that "feminine" characteristics necessarily define the works of women; there is little evidence that all male architecural work lacks them. Ms. Torre herself invalidates the theory. "It is still too early," she says, "to make wholesale comparisons between the achievements of men and women in architecture, from the perspective of artistic and theoretical creation." But the demise of the phallic tower and the master plan may be measure of some progress, she adds. — *S.J.N.*

Maturing Collaboration in Health Between Harvard and M.I.T.

The collaboration in health sciences and technology between M.I.T. and Harvard, epitomized thus far in the Joint Harvard-M.I.T. Program in Health Sciences and Technology, has matured to a new stage. Presidents Jerome B. Wiesner and Derek Bok have agreed to establish an Inter-University Division of Health Sciences and Technology.

All five schools at M.I.T. are listed as participants, as are Harvard's Faculties of Medicine, Public Health, and Arts and Sciences and the Division of Applied Sciences; Dr. Irving M. London, Professor of Biology at M.I.T. who has been Director of the Joint

Educational Counselors

Since its founding in 1951, the Educational Council has had seven executives but only one "office manager" to tell them what to do. The "office manager" — Mary J. Manning, Assistant to the Director — retired in June, and six of her seven former bosses returned to Cambridge for a private dinner party to wish her well. Seated, left to right: Bruce F. Kingsbury, '44 (1954-57), Ms. Manning, and Peter H. Richardson, '48, Director of Admissions. Standing: Joseph A. Edwards, '72 (1976 —), James H. Eacker, '55 (1960-62), William J. Hecht, '61 (1968-76), William H. McTigue, '54 (1964-68), and D. Hugh Darden (1957-60, 1962-64). Absent: Arthur L. Bryant, '44 (1951-54). The dates in parentheses are those of service as Secretary, Executive Secretary, or Director of the Council.

Program, is now Director of the Inter-University Division.

The Division is considered an integral part of both universities, and the idea is to give a "stable institutional structure" to the collaboration, says President Wiesner. Since its founding seven years ago, the Joint Program has proved that Harvard and M.I.T. can "join successfully and productively in common efforts" in these fields, says President Bok.

The Division will have a governing board and a joint faculty committee, and most faculty members working in the Division will hold joint appointments in their "home" departments and in the Division.

M.I.T. Joins to Urge Reversing "Reverse Discrimination" Finding

Shall M.I.T. — and other universities — make special arrangements to assure the admission of fully qualified minority applicants?

The question will be argued before the U.S. Supreme Court next fall when it hears the University of California's appeal on the so-called "Bakke case" — the charge by Allan Bakke that his applications for admission to the University of California Medical School were rejected because of preferential standards for minorities.

M.I.T. is identified as sympathetic with a "friend of the Court" brief filed before the U.S. Supreme Court in June by Stanford, Harvard, Columbia, and the University of Pennsylvania; its purpose is to urge overturning the California Supreme Court's support of Mr. Bakke's position.

John M. Wynne, S.M. '56, Vice President for Administration and Personnel at M.I.T., explains: "The choice of minority applicants, from among those qualified for admission, contributes much to [the] diversity of the student body and introduces important perceptions and understandings into the educational process. Beyond that," his statement continues, "M.I.T. has a special responsibility as a major educational institution to enlarge the pool of well prepared minority men and women from which future leadership in all fields of our piuralistic society will be drawn."

Arthur D. Little Fund for Research

A $250,000 five-year grant from Arthur D. Little, Inc., will help fund new interdisciplinary research at M.I.T.

The Arthur D. Little Research and Innovation Fund, says John F. Magee, '51, President of the company, is intended to help the Institute "continue its initiative in ways that have made M.I.T. an international resource for creative research" and to "further the integration of science and engineering with management, public policy, and related social concerns."

Walter A. Rosenblith, Provost of the Institute, translated this to support for "new fields of research" and "new areas at the junction between traditional disciplines."

The grant, made in conjunction with the five-year Leadership Campaign, is the latest in a long series of benefactions to the Institute from Arthur D. Little, Inc.; the company was founded by the late Arthur D. Little, a member of the Class of 1885 who was a principal advocate for founding the Department of Chemical Engineering.

Dr. Little himself left a substantial holding in his company to M.I.T. — worth $1.3 million when sold in 1953 to the Arthur D. Little Employee Retirement Trust Fund. A $100,000 grant in 1971 led to establishment of the Arthur D. Little Professorship of Environmental Sciences and Engineering. Earlier the company provided funds for a series of Arthur D. Little Lectures, for chemical engineering and nutrition research, for chemical documents, and for other purposes; and Arthur D. Little, Inc., has been a member of M.I.T.'s Industrial Liaison Program for more than 25 years.

For Good Graduate School Teaching

Everyone worries about good teaching for undergraduates; now the Graduate Student Council has gone on the offensive to urge better teaching for graduate students, too. Hence the new G.S.A. Teaching Awards, for "effective and dedicated teaching of a graduate-level course"; the idea, says G.S.C., is to "focus attention on faculty who devote increasing time and resources to improved teaching."

The winners for 1977: Sheldon J. Axler, C.L.E. Moore Instructor in Mathematics; Arnold E. Barnett, Ph.D. '73, Assistant Professor of Operations Research and Management in the Sloan School of Management; Edward N. Lorenz, Sc.D. '48, Professor of Meteorology; James H. McClellan, Assistant Professor of Electrical Engineering; Amedeo Odoni, '65, Associate Professor of Aeronautics and Astronautics; and Charles N. Satterfield, Sc.D. '46, Professor of Chemical Engineering.

Four New Appointments

New titles — and new jobs — have come to four members of the M.I.T. community this spring:

☐ **D. Hugh Darden,** who came to M.I.T. in 1957 as Director of the Educational Council and since 1962 has been Institute Estate Secretary, is now Director of Planned Giving and Adviser on Legal Affairs. He'll help individual donors to M.I.T. in the area of planned giving and serve as a major contact point for attorneys, trust officers, and others concerned with gifts, life income plans, and bequests.

☐ Walter E. Morrow, Jr., '49, who became Director of Lincoln Laboratory early this year, has chosen two members of the Lincoln staff to help him as Assistant Directors: **John V. Evans,** Associate Head of the Laboratory's Aerospace Division, and **Donald C. MacLellan,** '57, Head of the Communications Division. Dr. Evans will be responsible for advanced research in solid

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I regret having to inform you of the death of **George H. Magee** on September 5, 1975, at De Bary, Fla. He attended Groveland (Mass.) High School before entering M.I.T. After graduating from Tech, he was employed by the Western Electric Co. from 1910 to 1912. He then went to work for the E. L. Phillips Co. in New York City. In 1917 he joined the Army and served until 1919. Following World War I he worked briefly for several engineering companies but in 1921 he rejoined the E. L. Phillips Co., and remained with that organization and its successor (Long Island Lighting Co.) until his retirement in 1953. George attended several of our reunions and was looking forward to our 65th. However, on the first day of that reunion, he phoned, from Florida, to say he couldn't be with us. He had gone there due to the illness of both his brother and sister and he felt that he should remain there with them for awhile. Within three months, George had a fatal heart attack, and he died on September 5, 1975. — **John B. Babcock**, Secretary, 33 Richardson St., Portland, Maine 04103

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Jonathan Noyes has a new address: 1907 Charles Circle, Edinburg, Texas. 78539. . . . **Harold Brackett** reports, "the weather in Florida this spring was perfect. We caught all the whiting we could eat." Harold and his niece Eleanor Forbes are now back at the old homestead in Maine. He says the season is ten days to two weeks ahead of normal. He is anxiously waiting for a man to do his plowing, after which he will be plenty busy planting.

Three very interesting letters help to fill up my space in this issue of the *Review:*

Rock Comstock writes: "Your Strathmore stationery brings back pleasant memories. I worked in that mill in West Springfield during the summer of 1912, with the help of my friend 'Jet' Samburn — whose father was manager — and with the necessity of another half year for my degree. I roomed in the local Y.M.C.A. and slept in the bed normally used by the Secretary, an East Indian who insisted on sleeping on the floor.

"No one could be more proud of having gone to M.I.T. I loved Boston, and still do — Copley Square with the library and its beautiful Grail, the old art museum and the (muddy) tennis courts behind it, the Old South Church where Duffett and I frequently went, the old Cotton Mather Church long since removed, the old Rogers Building with those worn brownstone steps, the house where I roomed, now the first house on St. Botolph left intact after the demolitions for the turnpike extension.

"I eventually married the youngest daughter of our landlords, a New Brunswick English woman and a Scotsman. After she died, I joined every theater club in the city, including the Charles Playhouse, but finally the late night trips back to

New Engineering Center in Honor of Purdue's Andrey A. Potter, '03

The name of Andrey A. Potter, '03, has been prominent in the annals of American Engineering Education since 1920, when Professor Potter became Dean of Purdue University's School of Engineering. He held that post for 33 years, one of the longest tenures of an engineering dean in any American university; and since he retired in 1953 Professor Potter has continued to be an active and revered member of the Purdue community — and a leader, too, in the American Society of Mechanical Engineers.

Now Professor Potter's name has been given to a major new facility on the Purdue campus which houses much of the School of Engineering which, as Dean, Professor Potter did so much to build.

The A. A. Potter Engineering Center contains a unified engineering library, flexible research space for various interdisciplinary studies, a television studio-classroom unit to serve the Indiana Higher Education Television System, and a suite of biomedical laboratories.

In his dedication address, George A. Hawkins, Purdue's Vice President Emeritus for Academic Affairs who earlier succeeded Professor Potter as Dean of Engineering, called Professor Potter "a living legend . . . a man who has brought more real honor to Purdue than any man now alive."

At the age of 94, Professor Potter continues to make daily trips to his office on the Purdue campus. He was twice offered the presidency of Purdue but declined both times, apparently preferring the life and work of an engineering educator.

Andrey A. Potter, '03, a living legend at Purdue University.

Members of the Class of 1916 at their 61st Reunion at Chatham Bars Inn this June (front, left to right): Betty Crowell, Beatrice Binger, Walt Binger, Charlie Lawrance, Frances Shepard, Bettina Robertson, Ralph Fletcher, Sibyl Fletcher, Hope Curtis, Barney Gordon, Francis Stern, Frances Duff, Paul Duff, Marjorie Webster; (rear, left to right) Bruce Crowell, George Crowell, Gene Gordon, Vi Alberghini, Lois Lawrance, Al Alberghini, Henry Shepard, Doug Robertson, Jackie Curtis, Steve Curtis, Rose O'Brien, Muriel Curtis, Theron Curtis, Smitty Curtis, Don Webster, Bob O'Brien.

Milford in all kinds of weather dampened my enthusiasm, along with my dependence on a '51 Ford of questionable performance.

"A life-long Republican, I voted for Carter and believe that with cooperation from the politicans in Washington, he has the potential of becoming one of our greatest presidents.

"I have two obsessions: 1) the Soviet menace and our imbecilic disregard of the seriousness of the situation. 2) E.R.A., the women's rights amendment and the attitude of so many of the middle-class married women toward it. I want so much to be around for another five years when (I hope) this will be ratified."

Henry Foley is having his own reunion and will not be with us at Cambridge. He writes, "We cannot attend our reunion this year because we have plans to be in Washington to attend a family reunion with our sons, grandchildren and one new great-grandchild. We have four sons, 15 grandchildren and 2 great grandchildren living in various parts of the world.

"Our oldest son, Henry, Jr., is Professor of Nuclear Physics at Columbia University and is on several U.S. missions for atomic weapons. Our second son, Arthur, was a foreign service officer for the State Department (recently retired) and has served in embassies in Europe and South America. Our third son, Robert, is an executive of Ford Motor Co. in the International Div. in South America and South Africa. Our fourth son, John, is a lawyer in Kalamazoo, Mich. Previously, he served in the U. S. Navy fleet in the Pacific war area. As you can see, our sons are world oriented because of service in various parts of the world.

"The major part of my business activity was spent with General Motors Corp. After retirement at 65, I became a consulting engineer for the city of Flint, Mich. Now we are finally retired in our home here in Birmingham."

Cornelius Duyser writes, "I've only been to one reunion, and that was many years ago in Pittsburgh. I was working at Oakmont at the time, so I took it in. We had dinner at a swanky hotel which cost us $8.00 apiece, and afterwards I stopped at a "quick and dirty" and spent about 20¢ to get something to eat.

"Now I can get along without a walker. I've had both eyes operated on, and it evidently will be some time before I can see clearly. I hope you will write to me in care of my daughter, Mrs. Emma M. LaPine, 155 Terry Road, Hartford, Conn."

Larry Cummings, Secretary, R. R. 4, Connersville, Ind. 47331

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Ray Dinsmore reports that, after being ill last winter, he is feeling much better. . . . **Alden Waitt** writes, "I retired as Chairman and President of the Art Institute on May 10. I decided 18 years was plenty. However, I continue to put in several hours a day and seem to be useful without the responsibility. I can use my old office, which is also a roomy studio, so I am doing more painting than in the past two years (and better, I hope). Also, I am working on a third lithograph, and have been invited to exhibit my work at the Institute gallery next autumn." Alden goes on to say that he noticed in a recent *Technology Review* that the 1914 notes were on the first page of the class news section, and adds that that "would seem very official and definite warning that we have aged rapidly recently." . . . **Harold Mayer** is now living at the Commodore Hotel, Portland, Ore., 97205. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

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Azel Mack, Secretary of the Class of 1915, who suffered a stroke early in May, is making good progress toward recovery and will resume his regular reports in *Technology Review* in the fall. A gathering of the Class set for Technology Day, June 10, was postponed until fall. Mail will reach Mr. Mack in care of his regular address, Apt. 26A, 100 Memorial Dr., Cambridge, Mass., 02142. — *J.M.*

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It rained on Monday, was cloudy and drizzly on Tuesday; that night there were breaks in the clouds. On Wednesday we awoke to bright sunlight and it stayed with us until after we departed from the Chatham Bars Inn on Thursday. Fantastic — 1916 weather had again prevailed for our reunion. As soon as we left the Cape it started to rain and in the next three days they had five inches of rain and 50-mile-per-hour gale winds.

The class picture which appears elsewhere on this page identifies those who attended. We were particularly pleased to meet for the first time **Barney Gordon**'s son, Gene, and **Theron Curtis**'s two sons, Steve and Smitty and their wives, Jackie and Muriel. We had last minute cancellations from Dorothy and **Dave Patten** (unexpected conflict) and **Nat Warshaw** (arthritis kicked up). . . . This nice letter from Mildred and **Frank Holmes** was waiting for us at the Inn: "Please convey to the classmates our very best wishes and express our regrets at being unable to be with you. Mildred developed a breast tumor and was in Mass. General Hospital during the first week in May. Fortunately the tumor proved to be benign. We are most grateful. We expect to spend considerable time this summer at our cottage in Fitzwilliam, N.H." . . . Also awaiting us was this letter from Helen M. Lovenberg, daughter of our deceased classmate, **Al Lovenberg**: "It's that time of year again, when the '16ers meet at Chatham Bars. How wonderful for all who will be in attendance. The blazer presented to me at the 1966 reunion still gets good use. People are confused to see '16 on the crest — guess they think I'm pretty well preserved! My mother, Frances, died while I was in Europe last summer attending a Zonta Int'l. convention. The *Technology Review* continues to make its way to my door, and I read avidly the '16 news. Along with your classmates I will miss the efforts of **Harold Dodge**."

We also heard from **Charlie McCarthy** who wrote: "We must reluctantly forego the pleasure of being with you and the other old friends who will be there. Please express our regrets to them and our best wishes that the reunion will be a very happy event." . . . **Betty McCarthy** suffered a bad fall with painful injuries to her arm, leg and shoulder, so they cancelled their plans to attend. The letter also indicated the good news that Betty was showing substantial improvement although the bruises "seem to take forever to heal." . . . We were sorry to get this card from **Jap Carr**: "Just can't do it this year." . . . **Dan Comiskey** sent his "Best Wishes to all. Very sorry but just can't make it this year." . . . **Vert Young** wrote: "The **Art Shueys**, my sister, my wife and I are going to attend the M.I.T. 'College Course' at Aspen in July." . . . **Willard Brown** wrote, "Sorry, but it is simply impossible for me to be with you in 1977. I will be very much tied up here the evening of Tuesday, June 7. That is the date (the first Tuesday of each month) that our local Santa Barbara Chapter of the Illuminating Engineering Society holds its dinner meetings. I first met the I.E.S. when they had their 1920 annual Convention in Cleveland. The next year in Rochester, N.Y., I had a formal paper on their program. After that I've never missed one of their Conventions except for 1962 and that one because we thought my Alice was having a heart attack! Well, now I discover I am the oldest living Past-President of the Illuminating Engineering Society! In the ten years since I have been in Santa Barbara, I have of course been active in our local I.E.S. Chapter, usually serving on their Board of Governors as a sort of senior adviser. On June 7 they are holding a Willard Brown night, with the ladies present, at our Santa Barbara Biltmore. I will be thinking of you." We sent from Chatham a message of congratulations to Willard from his classmates.

The 61st was another happy reunion. Over the years, we have become very close and it's a great joy to see each other and share a couple days of relaxation and stimulating conversation. **Francis Stern** and **Paul Duff** continue to regale us with their humorous stories. . . . **Walt Binger**, who will celebrate his 90th birthday next January, amazes us with his abounding energy and limitless enthusiasm. He still rides regularly and only a week earlier he had enjoyed a three-and-a-half hour horseback ride over the countryside. Temporarily he has to bypass the big jumps over stonewalls and fences while a mild back strain improves. However, we're guessing that it won't be long before he'll be back in the hunt and soaring over the barriers with the best of them. . . . **Henry Shepard** continues his interest in antique cars. Bob O'Brien met Henry at the Heritage Plantation of Sandwich, Mass., and Henry took Bob into the Antique Car Museum there and showed him a 1910 Cadillac on display that Henry had owned and restored several years ago. . . . **George Crowell** continues to be active with his son, Bruce, in their construction business. . . . **Hy Ullian** continues to be active in his Land Survey Business. . . . **Barney Gordon** and **Doug Robert-**

son also are actively involved in their various enterprises. . . . **Francis Stern** had to hurry to Boston Wednesday afternoon to meet his wife Gladys. They both had appointments for their eyes with specialists and the early report is that they both got good news. Francis was without sight for several weeks last winter but fortunately this was overcome and he was seeing very well at this reunion. . . . **Frances Duff**, who experienced heart trouble at our 60th, returned this year in great shape.

Several of our classmates enjoyed reading *Days of Beauty*, a collection of poems and verses by Gretchen B. **Gore**. **John** and Gretchen always attended our reunions. Last winter, Gretchen died. The poems and verses were written and sent to her son over a period of years and after her death were incorporated in the little booklet. . . . We regret to report the death last May of our classmate **Richard G. Berger**. Many of us remember that he was the early leader in the campaign against cigarette smoking as a cause of cancer. He financed, wrote and distributed literature on this subject beginning in the 1940s. He will also be remembered as a double for Harry S. Truman and regularly appeared at parades and functions as "Give 'Em Hell, Harry." We'll miss him.

Continue your cards and letters. Good health and happiness to all and as Cy says "Keep Breathing." — **Ralph A. Fletcher**, Acting Secretary, West Chelmsford, Mass. 01863

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Congratulations to Joshua **Littlefield** and to his dad **Joe**: Joshua has been admitted to this fall's freshman class at M.I.T. . . . **Jack Wood** has a tough schedule in San Diego: he sails on Wednesday with some old cronies, Sundays with Helen and friends, and on Tuesdays and Saturdays he teaches little kids and young wives. He does get in some yard work, too.

A delayed notice of the death of **Ted Burkhart** appeared in the December Notes. His friend, Evers Burtner, '15, thoughtfully contributes the following information: Ted dropped out after his sophomore year to earn funds. Returning, he got his degree in Mechanical Engineering and went on for the first intensive course of Naval Architecture, after which he was assigned to the Boston Navy Yard. After employment at the Willamette Iron Works, he spent 30 years as chief design engineer for the American Can Co. at Portland, Ore.

John DeBell writes: "I had not planned on our 60th, because the idea of travel becomes increasingly abhorrent. But meanwhile my 81-year-old appendix decided to kick up, and in the resulting fracas we came to the parting of the ways, so I put in a couple of weeks in the hospital instead." The Connecticut General Assembly saw fit to adopt House Joint Resolution No. 41 Jan. 26, 1977, which stated, "Whereas John M. DeBell was inducted into the Plastics Hall of Fame for his significant scientific and technical accomplishments in plastics and for inspiring and leading others in the field," and five other "whereases"; ending "Now therefore be it resolved that the members of this assembly unite in commending John M. DeBell for his induction," etc.

With regret the death is recorded of **Edwin R. Hanson** at Jaffery Center, N.H., on April 24. He spent many years with the City Service Corp. — **Stanley C. Dunning**, Secretary, 6 Jason St., Arlington, Mass. 02174; **Richard O. Loengard**, Assistant Secretary, 21 East 87th St., New York, N.Y. 10028

18

My season's greetings at last year's end have yielded rich dividends. For example, a report from **Georgius Cannon**, is the sort of thing that makes us privileged to be part of the M.I.T. family — associated with so many who have made real contributions to our communities, to our professions, and to our standard of living. I wish I could reproduce his hand-written letter — at 85 it is firm, vigorous, and indicative of a strong character. He writes, "I retired from my architectural practice two years ago. Then in January of last year, as part of the Bicentennial, a project was started to build a concert hall for the Utah Symphony Orchestra and a fine arts center. I was appointed as architectural adviser to the committee. I wrote the program for the work, helped in the selection of an architect, and advised during the progress of the working drawings. My 55 years as an architect have contained lots of stress, and I have had to start over seven times due to depressions, wars, and other reasons. But, as a profession, architecture has been rewarding and I have had a wonderful life. I have loved my work and have always loved being alive. All in all, I wouldn't have missed it for anything.

"As is usual for M.I.T. graduates, I have received some honors. I am a Fellow of the American Institute of Architects and a Fellow of the Utah Heritage Foundation. Last year the Utah Heritage Foundation made me a Life Member, their highest award. Before I went to M.I.T., I attended the University of Utah for two years. Last year they gave me a distinguished alumnus merit award. Also last year, the Utah Chapter of the A.I.A., for the first time in their history, gave me an 'award of appreciation.' I am also the only Utah architect to be listed in *Who's Who in America*."

John Abrams, chemical engineer, (active conservationist in California, and a most loyal member of our class) submits his interesting and forthright comments: "I am taking philosophical viewpoints in espousing community causes and emerging national and world problems. Life style in a far western mountain community bears little resemblance to yours in effete Boston. This morning at breakfast I 'lifted up mine eyes' to the titanic majesty of the 14,000-foot Sierra Range, usually cloaked in snow. Then I turned to anxiously scan the T.V. screen's weather pattern. It gave us hope for a storm — the only relief for calamitous drought.

"Periled is the land in this beleaguered Owens River Valley. Only today, March 26, a high court put welcome constraints upon aqueduct exports to far-off Los Angeles."

How did John come to be in his "park-like setting along South Indian Creek, where my water wheel is faithfully paddling?" He begins that story with his grandfather and father in the oil business. So it was natural for John to come to Los Angeles during the California oil boom, where he "gave a helping hand to a fine young Los Angeles lawyer in putting teeth in the State's natural resources code with legislation to prevent waste of natural gas by burning in open flares." He's been a conservationist ever since — "Nature Boy Jawn," he calls himself, "who has been at it for lo, these unrecorded years." — **Max Seltzer**, Secretary, 60 Longwood Avenue, Brookline, Mass. 02146; **Leonard Levine**, Assistant Secretary, 599 Washington Street, Brookline, Mass. 02146

19

Word was received that **Louis J. Brown** passed away in Rutland, Mass., on August 30, 1976.

Frederick L. Hunter writes from Evanston, Ill., "I'm healthy and enjoying myself at 83. Financial security makes a world of difference." . . . **George Kahn** is still retired and does consulting work for the Brookline, Mass. Health Department. He plays tennis or squash three or four times a week, frequently with his grandsons.

S. Albert Kaufmann retired in 1976 after 51 years as a professional land surveyor and civil engineer. He still resides in Tewksbury, Mass., where he built a home in 1934. . . . **Ervin M. Kenison** writes: "I am alone in Bradenton, Fla., but not lonesome as I have a nice lady friend. I play bridge, euchre, rummy, and shuffleboard. Feeling good and enjoying my retirement. Florida weather suits me well."

Donald W. Kitchin and his good wife Evelyn wrote from Brunswick, Maine: "Don is home with me and doing so well, we cannot believe it. Came home November 29 and we got through the worst winter we have had in the 14 years we have been here. The bulbs are up and lots of birds returning so I guess Spring is here (early April). We are looking forward to seeing our great-grandchildren this summer. Our best to all. Don Jr.'s son was married in November. Fun to read the news in the *Review*!"

Dick Holmgren writes: "Got your note yesterday on our return from a five-week tour with Alumni Flights Abroad to New Zealand and Australia. On our way home we stopped over in Fiji, Papeeta, and a three-day stop at Bora Bora, said to be the most beautiful isle in the South Pacific. It is completely surrounded by a barrier reef. We enjoyed seeing the koalas, kangaroos, and walabees and fairy penguins. It was a great trip. We are both fine and enjoying life. We hope to make the 60th."

Word was received from his fraternity of the death of **Russell H. Savage** with no date. He was Head of the Western Michigan University Paper Technical Department, in Jackson, Mich., and prior to that worked with Mead Corporation in Chillicothe, Ohio. He graduated in chemical engineering.

Your secretary will be in Chautauqua, N.Y., in July and August (38 Peck Ave., Phone 716-357-2431) and back in Florida in October. Have a good summer. — **E. R. Smoley**, Secretary, 50 East Rd., 11E, Delray Beach, Fla. 33444

20

As a result of correspondence with **Dusty Miller**'s brother, Lloyd, I am able to contribute more information about our beloved Dusty's illustrious career. In World War I, Dusty was a lieutenant in the field artillery and continued his interest in the military, becoming Vice Commander of the Military Order of the World Wars in Phoenix. He became associated with Johns Manville Co. and was with them for over 30 years as their sales representative in Arizona. Dusty was an outstanding leader in his community. He was head of the Phoenix Rotary Club, later, District Governor; President of the Arizona Automobile Club and headed their travel department after which he conducted a travel agency. It was as members of one of the travel groups that he and Clotilde met their deaths in the Canary Islands. Dusty headed one of the eight major hospitals of Arizona and organized the group into a united facility. He headed the important water and sewer association of Arizona. He was a director of the Pacific School of Religion and other local colleges, a member of the Arizona Club and numerous professional, civic and social organizations. A memorial service for the Millers was held in Phoenix, at which a wide circle of friends and admirers were in attendance.

Some of the above information was contained in a thoughtful letter from France by **K. B. White.** I am happy to report that K. B. White continues exceedingly active, conducting courses and doing consulting work. At the time of his writing, he and Denise were looking forward to a visit from Ann and **Bink Carleton** who were stopping on their way to visit sons in Germany.

In case you didn't see it, an interesting story about **Harry Kahn** appeared in the local papers recently. Harry thought he had retired in 1965. However, his son submitted his father's name to the International Executive Service Corps that calls on experts such as Harry to lend their expertise to companies overseas who desire their assistance. Harry, with his long career in the ceramics field, found a spirited demand for his services and has accepted assignments in Iran, the Philippines (four times), Thailand, Greece, Korea, and Japan. Harry and his wife, Hannah, live in Oxbridge, Mass. He hasn't accepted any assignments recently, but who knows?

A pleasant letter from **Bob Tirrell** of 90 Bank St., Lebanon, N.H., expresses regret at his inability to make Alumni Day but says that Eleanor is fine and does a grand job of looking after him.

Captain **Harold J. Murray** of 4406 Sherwood Rd., Jacksonville, Fla., died on March 25.

It is refreshing to record that **Perk Bugbee**'s

A new honor came to Whitworth Ferguson, '22, early this spring: the 1977 Canisius College Distinguished Citizen's Award. Left to right, at the presentation: William D. Hassett, Jr., Chairman of the Canisius Board of Trustees; Leonard Rochwarger, Chariman of the Canisius Board of Regents; Mr. Ferguson, and the Very Rev. James M. Demske, S.J., President of Canisius. (Photo: David Dyviniak from Canisius College)

Honors to Whitworth Ferguson: "A Dominant Figure on the Niagara Frontier"

Whitworth Ferguson, '22, who has been a staunch supporter of M.I.T. ever since he studied electrical engineering here for two years with the Class of 1922, now holds the 1977 Distinguished Citizen's Achievement Award of Canisius College, Buffalo, N.Y.

Mr. Ferguson was cited as "a dominant figure in electrical engineering on the Niagara frontier for well over five decades. . . . Old as the century in years but enduringly young in ideas, imagination, and interests."

The award is given annually by the Canisius Board of Trustees to recognize "professionalism, civic participation, and community involvement"; Mr. Ferguson's is the 20th annual citation.

Mr. Ferguson founded the Ferguson Electric Construction Co., Inc., in Buffalo in 1935 ("A daring application of Andrew Carnegie's formula of expanding in hard times when costs are low to be ready when prosperity returns," said the Canisius citation) and the Ferguson Electric Equipment Corp. in 1953; he continues in active leadership of both. In addition, he's been a Director of Blue Cross of Western New York, Chairman of the University of Buffalo's Creative Education Foundation, Director and Chairman of the Buffalo Branch of the Federal Reserve Bank, Director of the Buffalo United Fund, and Trustee of Canisius College, the Fillmore Hospital, the Y.M.C.A., and the Albright-Knox Art Gallery.

lifetime service in the interests of fire prevention have been signaled by establishment of a Percy Bugbee scholarship at Illinois Institute of Technology, which includes in its curriculum a course in fire prevention. The scholarship was set up by the National Fire Protection Association.

Just ahead of the deadline comes a welcome letter from **Harold Hedberg** of 3333 N. E. 34th St., Ft. Lauderdale, Fla. Harold says that he was so taken with the dissertation on "Life Begins at 80" that he had a friend make a number of copies and spread them around. Harold says **Bob Sumwalt** would be pleased to know how much enjoyment it has given others around "that age." About a year ago, Harold and Elsie celebrated their 50th anniversary — his great grandson, aged 5½, was at the party and was found, after a search, behind the bar eating cherries. After that, they assigned a waiter to keep him from falling into the Intercoastal Waterway. Harold expresses the hope that I will be showered with notes from the class. At any rate I am grateful for this small trickle. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

Assistant Secretary Sam Lunden sent along to me a lengthy, fascinating letter from Edwin L. (Ted) Rose written just after "a long stay in the hospital under rather serious circumstances." Mr. Rose says he is "still very weak and shaky," but the letter gives no other limit. The entire letter deserves to be published but it's far too long. So we resolve that dilemma by summarizing the highlights; for a copy of the full letter, write the Editors of Technology Review, Room E19-430, M.I.T.

Ted began college in February, 1918, in electrical engineering at Caltech; he was so good in physical chemistry that "at the end of the sophomore year the whole chemistry faculty descended upon me en masse and tried to persuade me to change from electrical engineering," and failing to do so was "my first major mistake," because some of the most important matters with which I became engaged have been chemical projects."

By September, 1919, Ted entered Course VI-A at M.I.T. and came under the influence of such stimulating professors as Bill Timbie, Van Bush, E. B. Wilson, and Dinty Moore. He worked hard on mechanics, electrical engineering, and mathematics, with the result that "I could tackle any problem, including a large area in chemistry."

In 1923 Ted was research assistant in electrical engineering at M.I.T., then came a Charles A. Coffin Fellowship from General Electric, and Ted was back at Caltech teaching mechanics and math and conducting research into the effects of soft x-rays on the emission of electrons from metals. Then for four years he was Electrical Engineer with the Department of the Interior on the Hydroelectric power plant for the Coolidge Dam at San Carlos, Ariz. He came back to M.I.T. in 1929 to continue graduate study and research. Then it was back to industry for eight years starting in 1935 as Chief Engineer and Director of Research at Waterbury Tool — a subsidiary of Sperry Corp. When he started, there were 45 employees with a backlog of $400,000; and when he left, $2 million-worth of equipment later, there were over 2,500 employees.

In 1943 Ted was asked to join a committee to review the Manhattan Project in detail, and when that report was written Ted was asked to take charge of the Project's engineering program. But he turned it down; "one of my sad errors of judgment," he writes. Then came work at Raytheon in 1945 to plan an industrial research division; a successful effort with a group of friends to gain control of Diebold, Inc., which was engaged in developing microfilm equipment; and an assignment from the late Werner von Braun on the new rocket program. Later still he worked "on the side" with the late Vannevar Bush, '16, on hydrofoil developments for the Navy, with Miami Shipbuilding Co. as Director of Research on Hydrofoils, with his own group making the first catalytic oxidizing equipment particularly adapted to burn automotive exhaust gases containing lead, and finally with a group setting up a company to develop equipment for recovering gasoline vapor from refineries, distribution terminals and service stations.

Now Ted is involved almost full time with a coal gasification project, in connection with which he has filed some patents and formed affiliations with owners of about 10^7 tons of coal, an electric power company, a gas company, a pipeline company, and a couple of steel companies. "Resources are more than adequate and it finally appears I may enjoy something more than fun from the enterprise," he writes.

A letter from the Secretary of the M.I.T. Club of Tampa Bay tells of the election of **Helier Rodriguez** as President and **Elmer W. Campbell** as a member of the Board of Directors. Congratulations! A subsequent letter from Helier reported that "Graciela and I went to a picnic luncheon of the Sarasota M.I.T. Club where we had a most pleasant reunion with a few other '21-ers. . . . Claudia and **Josh Crosby** are coming to visit us on June 4 and we expect to gather together some members of the class who live nearby, for luncheon."

An Alumni Fund envelope from **George Welch** says "Irene and I keep going. We motored to California last September and spent February and March in Winter Haven, Fla. Summers we spend in Vermont at our summer home on Lake Champlain, and the rest of the year in Poughkeepsie near Vassar College.

Harold Cake of Tigard, Ore., wrote shortly after the death of **Dugald Jackson**. "There were 27 of us in the original Course VI-A headed by Prof. Timbie. I count about seven deceased and two or three unaccounted for. Four of us are on the Pacific Coast — **Bill Matthews** in Spokane, **Ted Rose** and **Ed Chilcott** in Los Angeles, and myself. We lived together in Lynn while working at the G.E. plant and at 95 Newbury St. in Boston. Since receiving our master's degrees in 1922 we've ended up in all types of occupations; eventually I became President of the 44th largest savings and loan association in the U.S., located at Portland. Quite a contrast to my original intentions, but that is the way the wind blows."

A note from **Grant Miner** of Los Altos, Calif., was written on Playboy Towers stationery from Chicago. "Wouldn't you know I'd wind up in Playboy Towers? Bunnies run around like crazy. I fooled them — I asked for a single room. Two representatives from Tokyo's Zenitaka Corp. picked me up and we flew into O'Hare yesterday. I'm an expert now on the slurry method for constructing diaphragm cut-off walls. We're going to be here a week, visiting construction projects, then off to Washington and Baltimore. Most interesting!" Grant was also invited to make a trip to Japan but decided against it."

We are sorry to report two deaths: **William M. Stratford**, Rancho Santa Fe, Calif., on Feb. 16, 1977; and **Manuel S. Vallarta**, Mexico City, on April 18, 1977. Stratford was President of Texaco Development Corp. in New York City for many years. Vallarta earned both S.B. and Sc.D. degrees at M.I.T. and was a member of the physics faculty from 1923 until his return to Mexico in 1948. He was a prominent physicist and founded the National Commission of Nuclear Energy in Mexico. Our sympathy goes out to the two families. — **Summer Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J., 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Shefield Cir., Sarasota, Fla., 33580; **Samuel E. Lunden**, Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

Mac McCurdy of Seattle had to cancel plans to attend our Reunion, but asked to be remembered to classmates — especially those who attended his wedding on graduation day in 1922. . . . **Eastman Smith** has written from Mountain Home, Ark., sending a picture of a seagull from Maine near his colonial home. He moved South because

he did not enjoy 10 months of winter. Eastman's enclosures of announcements of projects include "Accurate Eyesight — Refraction Testing For Prescriptions Now In Existence." This culminates 25 years of research and experimentation. His Xactometer for exact vision has been demonstrated twice before the Optical Society of America and once before the American Academy of Optometry. His wife, Alice, is a registered landscape architect and is the author of a bestselling book on landscape architecture that holds people spellbound. Eastman invites us all to join him and his newly discovered ideal area in Arkansas for a visit and to see Optone Instruments. . . . **William A. Tripp** tells us that he is retired and living in Sarasota, Fla. . . . We have heard from St. Petersburg that **R. A. Stone** of Clearwater attended the Spring meeting of the M.I.T. Club of Tampa Bay at Bradsford's Coach House. The group was entertained by the M.I.T. Logarhythms. . . . Your Secretary received this year's Distinguished Citizens Achievement Award from the Board of Regents of Canisius College in March. He is most honored. . . . The sympathy of our Class is extended to the families of **Carl H. Sebenius** of Pasadena and **Francis J. Laverty** of Boulder. . . . And now your Secretary and bride will push off in their new LeSabre for the excitement of the yet-to-be-famous 55th — with pen and note paper for tabulating the glowing account of our youthful activities. . . . — **Whitworth Ferguson**, Secretary, 333 Ellicott Street, Buffalo, N.Y. 14203; **Oscar Horovitz**, Assistant Secretary, 3001 South Course Dr, Pompano Beach, Fla. 33060

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Where to go on our 55th Reunion is still under consideration at this point in time, so why not send your comments to **Royal Sterling**, our worthy and active reunion chairman, at 1340 Warwick Neck Ave., Warwick, R.I., 02889. The events on campus include the Pops concert at Symphony Hall on the evening of Thursday, June 8, and Technology Day on Friday, June 9. We still could have a couple of days on the Cape, perhaps, referably before these dates, if we desire.

George Bricker is still publishing annual issues of Bricker's *International Directory of University Sponsored Executive Development Programs*, and updates this regularly by means of much travel here and abroad. . . . **John S. Keenan** writes that he retired from G.E. in 1965 but continued working part time as a management consultant for several years. His permanent home is at Smyrna Beach, Fla., and he summers at his place in Thunder Beach, Ontario, where most of his family live.

Philip Schwartz was awarded a Doctor of Education degree by U.C.L.A., in 1975, at the age of 80! Congratulations to you Doctor! . . . **Al Pyle** continues to travel. Last April he was in Florida with his sister Vicky, and before that he spent some time in Paris, France, visiting his married daughter Cynthia. Cynthia has her Ph.D. from Columbia University in Italian Literature, and her husband is a professor of linguistics at the University of Paris. Al continues to function as an electrical engineer having repaired a circuit breaker for friends in Rochefontaine.

Daniel Garrison Brinton Thompson reports that he is 78 years old, has three children (all doing well), seven grandchildren and no divorces in the family! He continues to be active in many charitable, educational, civic and church organizations. . . . We are indeed sorry to report the death of **John H. Little** of Belleair Beach, Fla., on April 10, 1977. Jack took his S.B. with us in electrochemical engineering. After graduation he worked two years with Johns-Manville, Inc., as a chemical engineer, then became an electrical engineer with General Motors Research Laboratory in Detroit. In 1933 he became Assistant Head of the Lighting Section and later became Accessories Engineer of the Chevrolet Motor Division. Later, until retirement in 1959, he took charge of the Chevroloet Patent-Legal Group. After retirement he became a member of the City Council of Belleair, Fla., and later was chairman of the Board of Adjustment in that city. — **Thomas E. Rounds**, Secretary-Treasurer, 990A Heritage Village, Southbury, Conn. 06488

24

We have learned from Allan Tarr '28, Chairman of the Virginias area for the Leadership Campaign, that **Ray S. Hamilton**, retired Union Carbide executive, is now rooted in Wirtz, Va. Ray volunteered to help Allan, setting a good example as a contributor himself.

As the months slip into oblivion, we realize that the number of living classmates is slowly approaching zero. Alumni Records reports the death of **John H. Carson** on February 2, 1976. He prepared at the U.S. Naval Academy and earned his S.M. in Mechanical Engineering with us. In 1949, he was an Admiral in the U.S. Navy, but we have no record of subsequent years. . . . The date of **Harry F. Estill**'s death is not known. He spent three years with us gaining his S.B. in Business and Engineering Administration. Some years after graduation he was a Major in the U.S. Army Engineers, European Theater. . . . **C. Sterling Webber** passed away April 4, 1977, in Loudonville, N.Y. He transferred from Tufts and was awarded an S.M. in Chemistry. Web was an instructor at the Institute, research chemist for Eastman Kodak, Fiberloid Corp., Monsanto, and manager of resin research for Behr-Manning Corp., Troy, N.Y. The latter became the Coated Abrasives Division of Norton Co., and as he lived nearby, we believe that he headed that operation until retirement.

At the spring meeting of the M.I.T. Club of Tampa Bay, St. Petersburg, Fla., March 30, **Clint Conway** was elected a Director. — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline Mass. 02146. **Herbert R. Stewart**, Co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

25

A letter from **Max King** reached me just after the June notes were completed. It brought the sad news that **Henry ("Chip") Chippendale** had died in Hartford, Conn., on April 4, 1977 after a long illness. Max recalled the 35th reunion at which Chip was the life of the party. It was about that time that Chip retired from his career with the oil refineries on the Island of Aruba. This gave Chip and Margaret time to travel, a favorite hobby for both of them. Max also provided information about himself: "I retired in January, 1976 from my work in sales promotion with the Carolina Steel Corp. That job for 22 years was a real pleasure for me, with plenty of challenge, plus the opportunity of relaxing when I felt like it by performing some structural design — thanks to Professor Spofford's training. During my last month on the job I had a chance to renew an acquaintance with **Paul Hess** during some meetings on a construction job in Greensboro, N.C., on which both of us were involved. A few years earlier Paul had retired from the Blount Brothers construction business in Montgomery, Ala., but they couldn't get along without him and called him back to head a new subsidiary in general contracting. In my case, I have given up climbing ladders on construction jobs and prefer activities that permit a seated position like contract bridge and chess." Max now lives at 99 Pasatiempo Dr., Santa Cruz, Calif., 95060. He would welcome a call from classmates passing through.

A letter from **Henry Sachs** notes that having married a Boston girl some 16 months ago he has been visiting that fair city frequently and through her has formed new friendships with Arthur Riskin, '32 and Bill Giddon, '24. He goes on to say, "Last October we took a trip to France where I had my wife inducted as a Chevalier of the Confrerie du Tastevue, the Burgundian gourmet society, where I hold the rank of Grand Officier. In February we flew around the world, primarily to take a two-week cruise on the Dutch liner *Prinsendan* though the Indonesian archipelago (highly recommended). After a week in Bali and a few days in Sydney, Australia, we ended up in Phoenix, Ariz., where I attended a Board of Directors meeting of the Council on Social Work Education. I took this occasion to visit with our classmate and my former roommate **Ed Piepho** and his charming wife Grace. They spend their winters in Sun City and their summers in Michigan. They are both fine and enjoying their retirement."

Tom Price sent a letter, dated July 25, 1940, he had received from **Glen Bateman**, fondly remembered by all of the class. Glen was responding to Tom's letter regarding our 15th reunion. He was at that time a Second Lieuenant in the South African Air Force and probably stationed in Northern Africa although the censor would not allow him to be specific. Perhaps many of you will find Glen's words interesting even at this late date: "As you can tell from my address I am now in the S. A. Air Force and have been since December of last year. I was rather surprised that they accepted me as I am certainly no chicken, but I guess they were pretty hard up for experienced pilots. Since getting up this way we have had a bit of excitement from time to time with bombing raids into enemy territory and I'm pleased to report we have been successful in inflicting considerable damage. Being shot at is certainly a unique experience but I guess I must have been born lucky. I'm often afraid that this war is going to keep us all busy for some time to come and when it's over the world position will probably be pretty chaotic so God knows when I will see America again. I must ask you therefore to give my kind regards to any of our classmates you happen to run into."

A change of address card from **Ben Oxnard** indicates that as of June 15, 1977 he will be located at 1408 Cornell Road, N.E., Atlanta, Ga. 30306. . . . I recently received a phone call from **Archer Nickerson** in Duxbury, Mass. In the course of our conversation I learned that Arch has strong ties to the town of Chatham, Mass. He is a descendant of William Nickerson who founded Chatham, coming here in 1656.

I would be remiss if I failed to mention the first annual dinner meeting of the M.I.T. Club of Cape Cod, held at the Wychmere Harbor Club in Harwichport on May 12, 1977 with 116 members and guests present. The class of 1925 was represented by Dorothy and **Ken Proctor** as well as your secretary and his wife Evelyn.

With sorrow I have to report that **George G. West** died at 3585 Fairview, West Linn, Ore., on July 1, 1976. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

At our 50th reunion, you will recall that Class President **Dave Shepard** expressed his thoughts about his term of office and the need for a new president after 50 years. He appointed a nominating committee of **"Pink" Salmon**, **"Mooney" Owen** and your class secretary. This committee wanted to act while the class was represented in large numbers and did so before Dave had finished his talk, presenting their single nomination, Dave — this time for life. The class, of course, unanimously voted for our permanent President. During the past year the same nominating committee felt that Dave would feel more comfortable with a vice president, particularly one from the area close to M.I.T. So Dave was consulted as well as **Jim Killian**, the one classmate closest of all to M.I.T. The idea was good, all agreed, and the one candidate who stood out with all qualifications was **Bob Dawes**. Bob has been a member of the Alumni Council for more years than I can remember and a leading light in the Worcester County Association. Most of all he has always been one of our most loyal classmates. So following Alumni Association protocol, Class President Dave Shepard was delegated by the committee to appoint Bob Dawes vice president of the Class of '26 and Bob has gracefully accepted. Isn't this great news! I wish someone would now find an

When Eisenhower Marshalled Science to the White House

A "memoir," not a scholar's treatise, is how James R. Killian, Jr., '26, describes *Scientists Serving Eisenhower: How Sputnik Brought Scientific Advice into Presidential Policymaking*. But Dr. Killian thinks his recollections of his years as President Eisenhower's science adviser and as the first Chairman of the President's Science Advisory Committee (P.S.A.C.) will be an important case history: how one President used scientific advice "in guiding the nation into the space age and in seeking Presidential control of military and space technology against all of the rampant forces, good and bad, of the military-industrial-Congressional complex . . ."

Dr. Killian's manuscript is finished — it's been a major preoccupation of his retirement years — and the book is scheduled for publication on October 4, the 20th anniversary of Sputnik, by the M.I.T. Press.

assistant class secretary. When **Austin Kelly** promoted that enormous sterling silver tray engraved with all of your signatures he locked me into the job. I must say that it is very pleasant to be the one with most class contact but there are times when it would be nice to coast a little.

This month we have a first — a letter from **Jim Drain**: "We are dividing our time between Ligonier, Penn., and Delray Beach, Fla. Usually, I come north four or five times during the winter, but due to trips to the hospital plus too-low temperatures up north, I was away all last winter. When I returned I found all my *Technology Reviews* from November to May waiting for me. Going through them all, I learned something about the '26 Class notes which makes them unique: they are written so that you can enjoy a bunch of them at one sitting! My sister Doris Hay is talking about coming to Rockport in August to give the Hay Trophy if it is still being contended for. If she does, I may join her, and if so hope to see you."

Tony Gabrenas has always been one of our loyal correspondents. This time it is a post card on which he says, "I am sorry to hear that Ruth has had trouble with her hip. One never realizes what precious things we have in life until we lose them. I am having trouble with my left leg and have lost the ability to walk. Have been in the hospital for a few weeks and am now receiving radiation therapy. It is getting better."

We have nice letters from **Ike Gleason** and from **John Ostborg** that we are deferring until next month because it is about time to leave for M.I.T. We rose early here at Pigeon Cove, in order to write and hand carry these notes to the *Technology Review*. It is three days before Technology Day and we want to double-check on the arrangements made for Open House at the Sailing Pavilion. Also the '26 video tape has been transferred to cassettes useable on special M.I.T. TV sets and it is time to get organized on editing that project. So with a usual "Cheerio" plus "Have a wonderful summer" we will take off. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

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As I write these notes in early June, Marion and I are all packed up and ready to drive to Wianno for the Reunion. The story of the reunion will have to wait for a fall issue of the *Review*.

I still have trouble getting used to the long lead time for class notes, and reminding myself when they will appear in print. In my editorial days, I worked on dailies and weeklies; in my first job after my degree I was writing for the Dow Jones News Service, where we used to measure the time between a news break and its dissemination over the wire in seconds (and try to beat the competitive wire service). But don't take that as criticism of the *Review*; most monthlies I know about have comparable lead times.

All I can tell you about the Reunion now is that, as of June 1, there were 92 classmates definitely signed up for attendance, plus two widows of classmates, and that 74 of the 92 were planning to bring their wives. The attendance will, therefore, be almost 25 per cent of the 380 known living members of the class.

The news gleanings from the Alumni Fund envelopes are rather skimpy this month. **Ed Mott** is still working with Planned Parenthood and the Senior Citizens. He has three children and ten grandchildren, presumably all planned. . . . **George Jenkins**, who spent one year with our class and then went on to take his degree from Bowdoin, writes that he will drop in at the Cambridge reunion; he lives nearby in Winthrop. . . . **Brad Stetson** is still enjoying retirement in Punta Gorda, Fla.

Percy Richardson divides his time between Venice, Fla., and Andover, N. H. He notes that he hears from time to time from **Fred Harrington** and **Robert L. Peterson** of our class. Fred is in a retirement nursing home in Bethlehem, Penn.; Bob is living in Santurce, Puerto Rico.

We have lost three more members of the class. **William K. Cave** died in September, 1976, little more than a year after he was named one of the outstanding retired employees of the Corps of Engineers, presented with an official commendation, and saw his portrait placed in the Gallery of Distinguished Civilian Employes of the Corps in the Office of the Chief of Engineers.

Harry M. Fitts died in April, 1976; he had spent most of his working career with the engineering department of the Sewer Department in the Borough of Queens, New York, but was living in Falmouth, Mass., at the time of his death.

Word also has been received of the death of **Gunnar A. Larsen**, whose address was Cement Limited, Dublin, Ireland; no date is given. — **Joseph H. Melhado**, Secretary, 24 Rodney Rd., Scarsdale, N. Y. 10583

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One of the nice side effects of **Jim Donovan**'s vigorous 50-year class gift campaign is the influx of news from his correspondents.

George Bernat reports that he and Ruth are in good health and hope to be at the big reunion next June. George saw **Vic Decorte** and Alice at the Florida Festival in Orlando last February. . . . **Harold Bialkowski**, writing from the State of Washington, says that he and Mary enjoy retirement and keep busy with outside work like logging, lawn grooming, and gardening. Most of their traveling is confined to Washington and Oregon but they did manage a trip to Sweden, England, France, and Italy last spring. . . . **Vic Logan** wrote but confined his words almost entirely to business.

In a bit of reminiscing, **Ted Pierce** writes that he, **Bill Murphy**, and Don Kennedy '24 (all from Con Edison) used to meet once each month for lunch at the Biltmore Hotel near Grand Central Station in New York City. Other '28ers in that group included **Frank Sweeney**, **Terry Hurlbut**, **George Flynn**, **Ray Wofford**, and **Don Sturznickle**. Ted and his wife Claire have a few of the usual age-related aches and pains but are otherwise well and busy. They have every intention of being at M.I.T. next June.

We were very pleased also to have correspondence from **Carl Loeb**. Here again, however, Carl kept strictly to the subject at hand — his contribution (a very generous one) to the 50-year class gift and Alumni Fund. We are hoping to see Carl at the reunion. . . . True to promise, Louise and **Ernie Knight** have gone back to England for another canal boat vacation. In 1978 they will forego both canal boats and freighters so they can join us in June in Cambridge. . . . Ann and **Ford Tibbetts** sent a postcard from Morocco where they had been touring for six weeks.

Olive and **Newt Foster** spent two of their winter months in Florida using their house trailer and campsites. They spent one month in the Flagler Beach area. It was colder in Florida than usual. . . . **Rene Simard** says that he is not working at anything now but does a fair amount of traveling to such places as Tahiti, Martinique, Corsica, Hawaii, and Cancuc (Mexico). He still plays tennis and does some cross-country skiing. His two youngest children are still in high school. He is looking forward to June, 1978.

"The 1977 recipient of the Frank J. Osborne Memorial Award will wear the mantle of prestige comfortably and with dignity, for during the years that are past the accolades and honors that have come to her are legion." Thus began the citation as the distinguished award was made to **Roberta Lovely Halligan** on April 21, 1977. This most recent honor goes to Roberta for meritorious achievement in public health. This has been her professional field almost from the time of graduation in 1928. Next year she will complete 50 years of outstanding service in the State of New Jersey. To you, Roberta, our hearty congratulations!

With deep regret we must report the deaths of four classmates.

Joseph S. Farwell died on February 4, 1977. At the time of this writing no detailed information was available.

Holmes Iveson died March 31, 1977. His wife, Virginia, said that he had had a stroke and was ill

for about 14 years. In his professional life Ivy was an industrial engineer with U.S. Envelope Co. He was active in the fraternal order of Masons.

William S. McClintic died March 28, 1977. We talked with Bill's sister by telephone and learned that his death resulted from injuries received in an accident as he was driving to Florida. Bill was an engineer with the Federal Power Commission and had retired only a short time before his death. He was active in a number of professional and social groups.

Owen Rideout died December 1, 1976. His wife Irene reported that Owen had been retired for seven years and was apparently in good health. He enjoyed golf and cross-country skiing. It was while he was helping to clear out a ski trail that he was stricken ill. Owen leaves also his daughter and two grandchildren.

To each of the families we extend our heartfelt sympathy. — **Walter J. Smith**, Secretary, 37 Dix St., Winchester, Mass. 01890.

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Gordon R. Williams retired from full time consulting responsibilities in June, 1976. He has been reasonably active on a part-time basis. In the interim, he has taken a long trip to Brazil and several trips to the islands of the Caribbean. He plans to stay in the New York area. . . . **Arnold S. Wood** and his wife Barbara are well and happy, spending the winter months (January to May) on the West Coast of Florida and the rest of the time in beautiful Winnisquam, N.H. They have a visit from their daughter occasionally as well as from their son, who is a vice president of State Street Bank and Trust Co. in Boston. They are looking forward to our forthcoming 50th Reunion

Laurence R. (Larry) Moses and wife Kay married off their daughter Kathy on February 26, to David A. Bianchi of Scotia, N.Y. The newlyweds plan to live in Chapel Hill, N.C., where David is going to work. Larry and Kay plan to have their annual two-week trip to Scandinavia in September, followed by a motor tour of Germany, Switzerland, Italy, Yugoslavia, and Austria. While in Germany, they plan to visit their son Laurence, who was recently promoted to colonel, regular infantry, on April 1, 1977, and is a deputy commander of the 56th F. A. Brigade. They are in excellent health and enjoying their retirement in the fullest. . . . **John Happel** has sent a note saying, "I have been very busy, spending my time between Columbia University where I do some teaching and in New Jersey at a small research company which I organized when N.Y.U., where I used to teach, folded up. In between I play some tennis. We try to go to the Caribbean once or twice during the winter. This year we went to Antigua. Wife Dot plays the violin in Greenwich with a girl whose husband owns a hotel there. My children are now 19, 21 and 23. We have just bought a summer home at Lake Placid where Dot also plays the violin during July and August." . . . **Dexter T. Osgood** writes, "We are enjoying our retirement, with travel being the principal hobby. Last summer we toured eastern Canada, including Montreal, Gaspe, and Nova Scotia. While in Montreal, we were able to view many of the buildings and installations that were being built for the Olympics. Last fall we spent a couple of weeks at our favorite spot in the Caribbean — Little Dix Bay. In the very near future, we plan to cruise part of the Mississippi. Our best regards to all." — **Karnig S. Dinjian**, Secretary, 10 Ancient Highway at Plaice Cove, Hampton, N.H. 03842

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Another of our classmates has moved to one of the increasingly popular retirement communities. **Irving Dow** writes that after a serious illness last year he and Ruth decided their three-story house was too much for them and moved to such a community. I was a bit confused by the fact that he referred to it as "Leisure World" and enclosed a clipping which calls it "Rossmoor." In any event, it is in Silver Spring, Md., has about 2,400 residents and is a very busy place. Irving has joined the Kiwanis and Camera Clubs which are both active with work associated with the retarded and has prepared a series of slides which he uses for presentations to other groups interested in working with the retarded. He reports that **Oliver Green** is living in the same community, that **Charles Flint**, who retired from the New York Telephone Co. several years ago, is back at home after a series of operations he had last December, and that **Myron Smith** "braved the winter at his home on Lake Sebago, S. Casco, Me., again." In January, Janet and **Lou Verveer** came to the Washington area to visit their children.

Louise Dingwell who lives in Riverside, R.I., and has a real estate office in Little Compton which is "across from Newport," writes that if any members of the class would like to acquire a small estate where there is plenty of accessibility to Boston and New York, good golf, fine fishing, and low taxes, they might advantageously contact her at Box 564, Little Compton. . . . **Elizabeth Rossman Everett** has retired from teaching the new math and is currently watching the progress of Women's Lib "with a nostalgic (but jaundiced) eye." The Everetts live in Manhattan where Elizabeth's husband Edward practices law, but also have a home at Falmouth on Cape Cod. She has been trying without notable success to get her "lawyer husband to retire to the Cape and golf." The Everetts have a son Edward, Jr. who graduated from Harvard and is currently working toward a doctorate in political science. . . . **Allen Shepherd** is still living in Woonsocket, R.I., where he is busy in local activities as a member of the Zoning Board of Review and president of the North Smithfield Heritage Association which has acquired the last one-room schoolhouse in northern Rhode Island for restoration and exhibit purposes. He and Virginia spent most of last winter in Funchal, Madeira, which they like better than Florida. "No extremes of temperature and quite inexpensive and charming."

As previously reported in these notes, **Win Hartford** has been teaching at Belmont Abbey College in Belmont, N.C. He writes that next fall he will reduce his teaching load to one course in environmental science and devote the rest of his time to environmental studies and consulting. . . . **Parker Starratt** is still an assistant professor of business administration at Nathaniel Hawthorne College in Hancock, N.H., and is active in ham radio with the call letters K1BUR. He is sharpening up his golf game for 1980.

We are sorry to report that **George Schatz** and **Bob Schildknecht** died in March. George and Bob both lived in Cincinnati, Ohio, for many years and practiced architecture there. Regular reunion goers will recall that Bob attended the 40th reunion with two sons and also came to the 45th. George was apparently active in the Cincinnati Chapter of the American Institute of Architects which has made a contribution in his memory to the M.I.T. Architectural Library.

We have recently received **Greg Smith**'s letter reporting the status of the effort to put together a respectable 50th Reunion Gift. As those of you who have been engaged in fund raising know, major gifts play a very important role in any such effort. The 50th reunion is manifestly a landmark event in the history of the class and I hope that those of you who are fortunate enough to be in a position to make a major contribution to this gift will seriously consider doing so. Greg and Dick and Ralph will be happy to supply you with any information concerning special giving plans that can be used in connection with the 50th Reunion Gift. Greg noted that he is still active in M.I.T. affairs, spending three or four days a week on a volunteer basis in the UROP Program. He reports that the "undergraduates at M.I.T. are fabulously bright but the financial crunch is really a brake on the school." — **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

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The largest-ever Alumni Day at M.I.T., June 10, comprised an excellent technical program and

Roland F. Beers Moves from Dean to President at 77

Roland F. Beers, '28, who has been Academic Dean and Chairman of the Board of Trustees at Ethan Allen Community College, Manchester, Vt., is now wearing a new hat: at 77, he's President of the College.

It will be no bed of roses, for Ethan Allen's problems are plentiful. At a press conference on his first full day in office, Dr. Beers was at pains to insist that Ethan Allen is no "sinking ship" — even though, he admitted, "some teachers have left" because of rumors that the school might have to close.

"We have great plans for enrolling students," Dr. Beers told Maggie C. Bucholt of the *Bennington Banner*, and he spoke of courses — such as business law and property management — geared to the needs of small business. And there is also talk of closer cooperation — perhaps even merger — with Southern Vermont College, also in Manchester.

Even if merger does not materialize, Dr. Beers says he intends to leave Ethan Allen (current registration, some 75 students) "in a better position to proceed independently," according to Ms. Bucholt.

When G. Peter Grant, '35, retired as his special assistant this summer, James A. Champy, '63, said "personal support and conscience" characterized his contributions to the Alumni Association. Mr. Grant (shown here with Mrs. Grant receiving good wishes at a retirement party) replied that it's been "the people who count," and he's "proud to have spent the last 11 years here."

Retirement (Again) for G. Peter Grant

G. Peter Grant, '35, who left one career as President of Grant Photo Products, Inc., and its successor businesses in 1966 to rejoin M.I.T., has now retired from his second career with the M.I.T. Alumni Association.

Mr. Grant came to the Alumni Association as Director for Clubs, responsible for encouraging the growth of M.I.T. club activities around the world and for organizing a series of regional conferences. Since 1975 he's been Special Assistant to the Executive Vice President of the Association, working on projects for James A. Champy, '63, and the Association's Regional Directors.

Ten years after graduating from M.I.T. in general engineering, Mr. Grant was President of Grant Photo Products, Inc., a manufacturer of photographic materials and operator of a nationwide chain of portrait studios. When the company was purchased in 1960 by General Aniline and Film Corp., Mr. Grant became Market Development Manager for its combined Ansco-Ozalid Divisions, a position which he left in 1965.

At M.I.T. Mr. Grant has worked closely for a decade with officers of M.I.T. clubs throughout the U.S. and — especially — with members of the Club Advisory Board, which he helped organize. He's retiring to a home which he is modernizing from a one-room school in Hancock, N.H.

the usual delightfully sociable lunch. At the Class of '31 table were Polly and **Ken Germeshausen**, **Madeline Anderson**, Harriet and **Bryce Prindle**, **Ed Hubbard**, Louise and **John Swanton**, Jan and **Larry Barnard**, and Margaret and **Al Ziegler** were also registered for the event.

One of the chief events of the Friday luncheon is always the 50th year class presentation of its class gift, which we had a chance to observe, having in mind our own coming up in just four years. In recognition of Harold Edgerton's activities at Loch Ness, the Loch Ness monster was adopted as thier class mascot. Be thinking of one for us! *Conversations at lunch.* Madeline, a math teacher for many years in the Brookline schools, is now retired and moving to an apartment at the Prudential. Ken and Polly are back from a Quarter Century Club trip to Israel which they enjoyed very much. Ken has just received his reappointment as Research Affiliate at M.I.T. for next year. He has been a member of the faculty of the Institute since 1933. . . . We hear that **Bob Martin** is moving to Florida. . . . We were saddened to hear that **John Ness** died recently.

Horst Orbanowski writes that he retired on January 31 this year. . . . **Thomas Pureka** says the M.I.T. Club of Cape Cod is now well established. They had their first annual dinner meeting on May 12, 1977, with Professor Robert W. Mann as their guest speaker.

If you want more and better Class Notes, let's hear from more of you. — **Edwin S. Worden**, Secretary P.O. Box 1241, Mount Dora, Fla. 32757; **Ben W. Steverman**, Assistant Secretary, 260 Morrison Drive, Pittsburgh, Penn. 15216; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, Mass. 02158

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Professor **Carroll L. Wilson** made national and international headlines at a press conference held in Washington, D.C., on May 16, 1977, when he stated, "The free world must drastically curtail the growth of energy use and move massively out of oil into other fuels with wartime urgency. Otherwise we face foreseeable catastrophe." The warning emerged from a two-and-a-half-year Institute-sponsored study that was conceived and directed by Professor Wilson. The study is titled *Energy: Global Prospects 1985-2000*. . . . Professor **Albert G. H. Dietz** was the recipient of the Man of the Quarter-Century Award as one of the outstanding contributors to building progress over the past quarter-century at the annual Building Sciences and Construction Technology Awards Dinner, held in Washington, D.C., April 28, 1977. The awards are the outgrowth of the 1975 celebration of the Building Research Advisory Board, National Academy of Sciences' 25th anniverary. At that time it was proposed that Board Awards be presented to those people in the building community who have emerged as leaders in the field.

D. M. Danforth advises that he retired at the end of 1975 from the Research and Development Division of The Singer Co. and is enjoying retirement much more than he anticipated, but is preparing to move south to a milder climate. . . . **Bruno Werra** remains active as the Engineering Services Manager of the Tri-Clover Division of Ladish Co., Kenosha, Wis. . . . **E. Harold Anderson** stays active in retirement with the Galilean Baptist Mission at Grand Rapids, Mich., as Board Member and Controller Missionary establishing a Bible Church in Hopkins, Mich., and Youth Camp Administator. . . . **Francis T. Gowen** retired from Raytheon in 1971 but between his law practice, contract painting, and carpentry he reports that he has little time to think of retirement. He had a wonderful time visiting German and Italian friends last September and expects to entertain them on the Cape this summer. . . . **Al Newton** headed for Australia and Taiwan in May, for consultation work on solar energy. Al started his development and test work on solar heating and cooling in 1937, and even though he retired in 1972, private industry and government still compete for his services as a consultant in the solar energy field.

The Alumni Records Office reports the passing of the following classmates: **Erskine G. Roberts**, December, 1976 and **Delano C. Cannon**, February 2, 1977. Our sincere sympathy is extended to their respective families. — **John W. Flatley**, Secretary, Apt. 204, 5100 Dorset Ave., Chevy Chase, Md., 20015

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A good response to the Alumni Fund drive has brought us a group of interesting items, as well as one sad item, the passing of our classmate **Thomas O'Callaghan** on February 4 of this year. . . . Some of our members are able to keep active professionally although officially retired. **Henry Andrews** continues to be active in his specialty of paleobotany, and is writing a history of the field. Last fall he taught a course in it at Aarhus University in Denmark. . . . **Jim Eder** was in Peking on July 28, 1976, when the earthquake struck China, and rumors spoke of one-half million dead in the city of Tangshan only 90 miles away. Jim was struck by the calmness of the natives; only the foreigners were visibly emotional. . . . Others report less exciting travel such as **David Tashjian** who retired from Lockheed Missile and Space in May, 1976, and spent six months touring England. . . . **Robert Elliott** has been retired since April, 1974. He was formerly Director of Research and Product Development for King Seeley Thermos.

Ernest Massa has been enjoying retirement at Pompano Beach, Fla., since 1970. He reports a misadvesnture with a ladder resulting in a broken wrist but by now the cast should have been removed and he should be back on the golf links. . . . **Bernard Stiller** writes from Paducah, Ky., that he is retired. . . . **Simon Malkin** summarizes his own career as 20 years with Raytheon, spent in both the Missiles Division and in the Microwave and Power Tube Division, as well as eight years with Badger Co., a Raytheon subsidiary. His son Stephen has received three degrees — S.B., S.M., Sc.D. — all from the Institute. He taught at the University of Texas, New York State University at Buffalo, and, currently, is at the Technicon (Israel Institute of Technology) at Haifa. — **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Chevy Chase, Md. 20015

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We are proud to learn that of the 92 new members elected to the National Academy of Engineering this spring, two were from our class: **Arthur R. Anderson** and **Edward Woll**. Arthur is with A.B.A.M. Engineers, Inc. of Tacoma, Wash., and was honored for "Leadership in prestressed concrete construction and in the design and construction of engineering structures." Edward Woll is with G.E. in Lynn, Mass., and was honored for "Contributions to the pioneering development and evolution of aircraft gas turbines."

A gift of William L. Abramowitz in 1961 has made it possible to establish the Abramowitz Concert Series, sponsored by the M.I.T. Department of Humanities. The Series brings distinguished artists and lecturers to M.I.T. On May 4, the Borodin Quartet from Moscow gave the Abramowitz Memorial Concert.

John Demo writes, "Am still doing a considerable amount of travel. Most rewarding is travel with a constructive purpose: volunteer assignments in less developed countries to help upgrade their technology and marketing in consumer products." . . . **Robert G. Clarke** reports from Winter Haven, where he is visiting, that he retired from the U.S. Bureau of Mines, Division of Non-metalic Minerals, on June 18, 1976. . . . **Donald B. Wood**, from Corpus Christi, Tex., writes: "Facing retirement from Reynolds Metals on December 1, 1977, after almost 28 years of service. I will be looking for consulting work in my field as still have two girls in school." . . . **Miller H. Wachs** writes from Bridgeport, Conn., "Retired from Sikorsky Aircraft (Helicopter Engineering) in March, 1975, after 32 years, and have been having the time of my life consulting,

generally in the field of aircraft reliability and maintainability." . . . From **H. William Parker**: "I retired last June. Since, we have traveled through Nova Scotia, Gaspe Peninsula, and Quebec. We spent the winter at Belle Vista, Ark., where we will be returning after selling our house in Rochester."

In the process of recruiting classmates for the 17th year of our golf tournament I had some very happy and interesting telephone conversations, which I would like to share. **Bill T. Barker** is keeping busy in real estate in the Orlando area, and reports that Mae got a hole-in-one on July 4, 1976. Bill is rejoining the Class Golf Tour. . . . **Gordon Scowcroft** is also involved some in real estate and some in consulting, lives at Longwood, Fla., and is rejoining the Tournament. . . . **James Libby**'s only golf is with the nine-hole office league at duPont. He is a year away from his retirement date of July 5, 1978. The July 5, 1978 date denotes 40 years with duPont, quite a record. James and Helen expect to see **James Parker** and Mary in Riverside, Conn., this summer. . . . **Henry B. Kimball** retired in August, 1976, and moved with Ellie to Walpole, N.H., a small town 18 miles northwest of Keene. He is presently consulting for Kingsbury Tool. Their home is on a five-acre plot overlooking the Connecticut River. . . . **Earl Peterson** and Adele are going on the M.I.T. Quarter Century Club trip to Scandanavia this August. Earl is one of the four classmates who are joining the Class Golf Tourney for the first time. The other three are: **Arthur M. King** who retired from the Mengel Co., Wood Products Division, in Louisville, Ky., five years ago and now has the time to play golf; **Henry F. King**, who is retired and living with wife Elsie in Chatham; and **Richard L. Parli**, who has a busy architects office in Arlington, Va. . . . **G. Donald Fenton** retired from U.S. Steel in Worcester on April 1 after 40 years. He limits his golf to nine holes with a company group. His son James is a junior at M.I.T. . . . News of **Carl S. Smith** came from his wife, who sees him on weekends. Carl is Executive Vice President of all American activities of B.A.S.F., and commutes from his home in Grosse Isle, Mich., to the company's headquarters in New Jersey.

Reid Ewing retired several years ago to Winter Park, Fla. He writes: "I am working on several interesting projects: a method to protect citrus and other Florida crops against freeze damage; a process for reducing the heat requirements for greenhouses; and a method for increasing the growing rate of greenhouse foliage by the use of chemical additives in the greenhouse atmosphere." He plays tennis now instead of golf and works with the local symphony, his church and the American Cancer Society. He has a daughter, Constance Cook, living in Wellesley, and a son Reid H. Ewing who is at M.I.T. working for his Ph.D.

Paul L. Gilmont of Cypress, Calif., has had a quadruple by-pass operation like mine three weeks before so we had quite a chat. He is looking forward to playing in the tournament next year. . . . **Dave Buckwalter** writes:"I have to admit that I am having trouble accepting retirement. Whichever direction I take, I do plan to learn how to play golf." . . . Biggest shock to all the golfers will be the news that **Ham Dow** will not be competing this year. He retired from G.E. in San Jose on May 31. The Dows have already sold their home and are moving to the San Diego area where they are house hunting. He warns everyone to stay on their toes because he'll be back next season. . . . **Henry Ogorzaly** will be retiring early next year and is sure he will have time to play in the Class Golf starting next year.

I am happy to report that the Class Golf in its 17th year will have more participants than ever — 30 to be exact. In addition to those already mentioned, the following are coming back into it after a lapse of years: **Lester A. Brooks**, **Robert W. Forster**, and **Wesley H. Loomis III**. It will be great fun. The key here seems to be when you retire, take up or refurbish your golf and join the crowd.

I have some sad news to report. **William F. Bennett** died November 26, 1976, in Richmond, Va. **Louis Edward Garono** died April 4, 1977, in Baltimore, Md. **Robert J. Anderson** died May 1, 1977, in Sarasota, Fla. On behalf of their classmates I am sending our deepest sympathy to the widows and members of the families. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

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Last time I commented that before you read those notes I would have been river running in Utah. Now I report to you from a motel room in Moab, after four days on a raft on the Green and Colorado Rivers ending in Lake Powell and another six days exploring Arches and Canyonlands National Parks. For this reason I have outrun my mail and have but one item of news to share with you: **Leonard Cohen** has joined Hughes Helicopter at Culver City, Calif., as a Staff Reliability Engineer. The Cohens are enjoying their new home overlooking the Pacific — a change from Illinois! Their address is 802 La Salina Place, South Oceanside, Calif. 92054. Ruth notes also that their son has been serving as a Kibbutz volunteer in Israel while she keeps the home fires burning and the garden tended.

Friends will be saddened to learn of the accidental death in April of Barbara Shainin, 17, daughter of Margaret and **Dorian Shainin**. Our sympathy goes to the parents and her brothers and sisters.

From here on your secretary will stay closer to home base and will be delighted to hear from any and all of you. I will be spending the summer cleaning up the score or more trees felled or broken in a disastrous March 22 snow storm. Any volunteers? — **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

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The latest member of our class to receive a degree is **Haskell R. Gordon**. Haskell, who is co-owner of the Fair shopping centers in Worcester and is running our 40th Reunion Class Gift Program, was awarded an honorary Doctor of Laws by the Worcester State College in May.

Charles Donlan is retired from N.A.S.A., as of July, 1976, after 38 years. Charles came to N.A.S.A. headquarters in 1968. He served as Deputy Associate Administrator in charge of Manual Space Flight, Director of the Space Shuttle Program from 1970 to 1973, and was part-time consultant to I.D.A. and W.A.S.A.

Bruce S. Old was recently involved in a discussion at the Cambridge Forum on "Should We Switch to Small Technology?" Bruce is Vice President of Arthur D. Little in Cambridge. He is currently Chairperson of the Panel on Appropriate Technologies for Developing Economies, a study sponsored by the National Academy of Sciences.

We received notice recently of the death of **Charles F. Connor**, who had been an executive of A. C. Lombard and Sons. He had been with the class for his freshman year before transferring to Boston University. — **A.L. Bruneau**, Secretary, Hurdman and Cranstoun, 140 Broadway, New York, N.Y. 10005

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Bob Casselman, who is Associate Director of the Boston Museum of Fine Arts, was elected to the Board of Trustees of the Metropolitan Cultural Alliance. . . . **James S. Bruce** was elected to the Board of Directors of Eastman Kodak Co.

Billie and **George Cremer** are about to visit Tokyo, Hong Kong, Singapore, and Delhi. George is scheduling a visit to the Taj Mahal under full moon, so, after his return to the U.S., we'll be expecting his full report comparing courting under a Boston moon in 1939 with courting under an Agra moon in 1977. . . . We are saddened by news, just received, that Col. **John C. H. Lee, Jr.**, of Cincinnati, died August 29, 1975. — **Hal Seykota**, Secretary, 2561 Via Viesta, La Jolla, Calif. 92037

W.H. Krome George, '40, Chairman and Chief Executive Officer of Alumnium Co. of America, couldn't attend the Corporation's luncheon in New York on December 3. So his Corporate Leadership Award (see *Technology Review* for February, pp. A1-A5) *finally came to him from Howard W. Johnson (left), Chairman of the Corporation, early this spring. Mr. George was in Cambridge to lead the annual meeting of the Corporation Visiting Committee to the Sloan School of Management, and President Jerome B. Wiesner (right) joined in offering congratulations.*

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Alive and Well: **N. Bruce Duffett**, mistakenly listed as deceased earlier this year, writes to say he is very much with us (and active in the Alumni Fund drive). He told us that it was the death of his father, Norman Duffett, '11, who died last December in his 80th year, which should have been reported. We wish Bruce many more years.

Alumni Fund Note: **Sam Cohen** reports that he has been with the Naval Research Laboratory in Washington, D.C., these past years.

AAAS Fellow: **J. Herbert Hollomon**, Director of the Center for Policy Alternatives at M.I.T. has been made a Fellow of the American Association for the Advancement of Science, "for his outstanding contributions to the metallurgical sciences, to the management of engineering and technology, and to the study of policy alternatives." Dr. Hollomon is the Japan Steel Industry Professor of Engineering in the School of Engineering.

More Fellows: Election to the National Academy of Engineering is the highest professional distinction that can be conferred on an engineer, honoring those who have made important contributions to engineering theory or who have demonstrated unusual accomplishments in the pioneering of new and developing fields of technology. Among those elected this year is **Stanley D. Stookey**, Corning Glass Works, for the invention of glass ceramics and photo sensitive glasses.

More Honors: The Building Research Advisory Board of the National Research Council honored 61 contributors to building progress over the past quarter century at the annual awards dinner in Washington, D.C. Among those selected are: **Robert W. McKinley**, PPG Industries, Inc., Pittsburgh, for service to the Advisory Board; and **George O. C. Lof**, Solar Energy Application Laboratory, Denver, for professional development in design and planning in engineering research.

Unto the Third Generation: **Charles W. Freeman** died May 1 in Providence, R.I., where he is survived by his mother and brother, as well as many children and grandchildren. Charles was active in real estate in Providence in years past and later operated the Royal Victoria Hotel in Nassau and a swimming pool accessories business in California. He served with the U.S. Navy during World War II. We note with special interest that Charles was the son of the late Hovey T. Freeman (M.I.T., 1916) and the grandson of John R. Freeman (M.I.T., 1876).

Two of a Kind: Name alikes make up our roll call this issue. Write to each other and let us have a copy. . . . **Henry A. Burr** Malibu, Calif.; **John G.**

Burr Norman, Okla.; **John S. Coleman** Washington, D.C.; **Robert Coleman** Pomca City, Okla.; **John R.V. Dickson** Annapolis, Md.; **Richard P. Dickson** Scottsdale, Ariz.; **Clark Goodman** Coronado, Calif.; **David R. Goodman** Hanover, Ind.; **Robert L. Hayes** Huntington, N.Y.; **Thomas B. Hayes** Corvallis, Ore. — **Frank A. Yett**, Secretary, P. O. Box 562, Long Beach, Washington 98631

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Newsmakers: **Courtland Perkins**, President of the National Academy of Engineering, was one of seven to receive honarary degrees from Lehigh University. He has been Chief Scientist for the Air Force and Assistant Secretary of the Air Force for Research and Development.

Beaver Tales: At the Spring Meeting of the M.I.T. Club of Tampa Bay, **Harold Radcliffe** was our only Class of '41 attendee. . . . I heard from an "old" Army friend, Charlie Steele ('42), who writes about our classmate **Hoadley Mitchell**, "Last week I had a very enjoyable visit with Hoadley Mitchell and his very charming wife, Ruthie. They were down in this area to soak up some sun to take back up to Edmonton, Alberta, where they've lived and worked in the 'oil business' for many years."

Molecular Biology: **Robert Sinsheimer** is in the news again. The TV program NOVA featured him extensively and an *Engineering & Science* article entitled, "Whither Molecular Biology?" Dr. Sinsheimer has also been appointed chancellor of the University of California Santa Cruz Campus effective September 1, 1977. He was recommended in his new position by our Classmate **David Saxon**, President of the University of California, who noted, "Robert Sinsheimer is a scholar of world-wide renown, and his appointment is in keeping with my commitment to excellence for the University of California."

Losses: Notice has been received that **Howard Stoner** and **Orison Pratt** have passed away. Our sincere sympathy to their families. — **Henry Avery**, Secretary, U.S.S. Chemicals, 2863 — 600 Grant St., Pittsburgh, Penn. 15230

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Morrie Steinberg of Lockheed Aircraft's Corporate Staff in Burbank was elected to membership in the National Academy of Engineering for his "contributions to the introduction of new and improved structural materials into aircraft and space vehicles." . . . **Jack Flipse**, President of Deepsea Ventures, Inc., is heading a team taking its 560-foot converted ore carrier *Deepsea Miner II* to a Pacific Ocean mine site 1,200 miles southwest of San Diego. Their goal is to bring up mineral-rich nodules from depths of up to 18,000 feet.

Russ Brown continues as Chief of Design Engineering at General Dynamics Electric Boat Division in Groton, Conn. . . . **Bob Curtis** is now principal partner at Curling Associates in Bridgeport, Conn.; his firm provides new technology and equipment to U.S. and Canadian steel mills. . . . **Sandy Peek** recently has returned to GTE's Sylvania Division and is "having a ball" running a small advanced engineering development group. . . . . **Al Hayes** has expanded his consulting engineering practice and now has offices in both Mountain View and Fullerton, Calif. Al gets around by flying his company plane from northern to southern California twice a week with side trips to visit clients in Nevada and in Arizona.

With their children married and moved out, Betty and **Charlie Speas** now live in an apartment north of Baltimore. Betty is a travel agent and Charlie's business takes him to Europe occasionally, so they have been doing some traveling . . . Couple of good, newsy letters from **"Hawk" Shaw**. After all those years with Wright-Patterson AFB Aero-Medical Laboratory, Massachusetts General Hospital, Cambridge Hospital, Harvard Medical School, University of Copenhagen, Rusk Rehabilitation Center and a short stint at Pahlevi University in Iran, "Hawk" has settled in New Ipswich, N.H.! He works mostly with law enforcement people and, as he puts it, "I do a little work as a country doctor and more as an expert witness in civil and criminal cases involving doctors. Most of my patients are the dead ones I see as medical referee, but I am still allowed to see a few live ones."

In one of his last official duties as President of the Alumni Association, Edward O. Vetter, '42, carried the mace and led the dignitaries in the procession at Commencement on June 6. (Photo: Dek Lee, '79, from Technique*)*

Ed Telling resigned from the executive rat-race in 1974 but found that he could not stand the peace and quiet so he is now working twice as hard in Cortland, N.Y., running a small specialty construction business which he purchased in mid-1975. . . . **Bob Fay** is still holding forth in Lakewood, Ohio, with three children at home and three in college. He is doing interesting patent work including carcinogen monitoring, TB testing, and coal desulfurization.

"Heinie" Shaw (this is our month for the Shaws!) is living at the beach in Hermosa Beach, Calif., and goes board or body surfing "every morning without fail." He also scuba dives, skis, and teaches winter mountaineering and advanced first aid. Also serves on the National Ski Patrol and wrote a seafood cook book which sold 40,000 copies! Sounds like the life-style which some of us only dream about. . . . **David Baltimore**'s family are all involved in radio and TV. He is running the stations from Kingston, Penn.; his son Terry is the third generation in their 53-year association with broadcasting. Daughter Lynn is with NBC's Grandstand and second son, Charles, joined the family enterprises when he graduated from Tech last month.

Lou Rosenblum continues his consulting activities applying mathematics to engineering of geometric sculptures and precise calculation of calorimetric properties. His wife, Sandy, is searching out and editing 19th century music.

Again, thanks to all who send news in on our "handy-dandy do-it-yourself" form. — **Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, N.Y., 10605

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Alfred Emond wrote: "After 29 years with Sherwin-Williams Co. as chemical coatings sales manager in the northwest, I retired at age 55, in September, 1976. We moved from Portland, Ore., to the most southwesterly tip of the continent, San Diego. We built a cedar, Dutch Colonial house right on the ocean where waves lash in the front yard. But I could not unwind, so I went to real estate school and am now a licensed associate making big deals. I also took out a license as a finishing consultant and have received a contract from an eastern firm for one week's work every five weeks. Now I am happily retired!" . . . From **Richard Haas** we received the following: "Present position — International Patent Counsel, Goodyear Tire and Rubber Co. Wife Betty (Wellesley, '45, Case Western Reserve, '69) is a psychiatric social worker in private practice after eight years' experience at the Akron Child Guidance Center. My daughter Susan, a Mt. Holyoke grad, is completing her second year at Harvard Medical School. Daughter Becky, a Syracuse University graduate, is a nursing consultant to the division of medical standards of New York State. My son Mark, who graduated Colgate, will enter the Harvard School of Design in September."

Hugh Parker, Managing Director of McKinsey and Co., Inc., in London, was recently elected President of the American Chamber of Commerce in the United Kingdom. . . . A recent article in the Connecticut supplement of the Sunday *New York Times* shows a picture of **Oivind Lorentzen**'s 46-foot sloop, *Froya* at its slip at the Indian Harbor Yacht Club in Greenwich, Conn., where Oivind is a member. He's done a lot of blue water sailing in this vessel. . . . I had a good reunion with **Bud Hathaway** and **Bud Cruckshank** at a recent Hartford M.I.T. Club meeting. The first Bud is with Bristol Brass, and the second is with The Stanley Works.

The class officers wish you a happy summer. — **Richard M. Feingold**, Secretary, 779 Prospect Ave., West Hartford, Conn. 06105

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News for this issue was so non-existent that we have been forced to share with you a letter we received some time ago and decided then to hold it for this occasion. It contents are timeless and its author a bona fide member of our class. It makes for light summer reading, too.

"Dear Melissa, I read with considerable interest that your husband **Newton A. Teixeira** has volunteered your services as Acting Secretary of our beloved class. Having not seen the Class of '44 mentioned in recent issues of *Technology Review*, I had begun to wonder if I might be the last survivor of that august body. I had also speculated on the possibility that there had never been such a class and that it had only been a bad dream. Hence my relief to find that you are the real live Class Secretary.

"I do not remember you at Tech, but I do vaguely recall your husband. He was one of those people who are always volunteering others to do work. One often finds this type of personality acting as chairpeople on church committees. Perhaps this is where you met him.

"My main purpose for writing is to appeal to your well-known reputation for fair play in bringing some sort of balance to your new column. If successful, it might set a whole new style for the entire periodical. Frankly, I have long felt that M.I.T. classmates are mentioned in the *Technology Review* on only two occasions — when they are promoted and when they pass away. The younger the class, the more frequently is mention made of promotion. As the class grows older, the articles start to get downright depressing. Perhaps you could provide a more representative cross-section of class news in your future columns.

"In keeping with this objective, I am passing along a few notes about our classmate Elmo P. Zap, who has just been fired as President of Barracuda Systems. The press release stated that he was retiring in order to be able to devote more of his time to church work.

"Actually, things have not been going well at B.S. since Elmo P. was promoted to President

three years ago. In fact, Elmo P. became well known in the industry for his abortive planning. The final blow came after Elmo P. introduced his controversial theory of 'regressive promotion.' Simply stated, he not only felt each manager should start at the bottom but that said managers should frequently revisit the bottom for tours of duty in the 'real world.' This doctrine was actively promoted at all management levels including his own. Needless to say this often caused confusion as to who was in charge of the company. Nevertheless, this situation might have been overcome if a member of the press had not observed Elmo P. pushing a broom on the loading platform on his most recent 'bottom' visit. Word soon got around that things were so bad at B.S. that even the president of the company had taken to working in the shop. Naturally this did not go unnoticed by market analysts, and Barracuda soon hit bottom. At this point the Board of Directors got out *their* brooms.

"I hope this bit of class news will prove useful in writing your new column." **Robert Clarke**, '44. — **Melissa** and **Newton Teixeira**, Class Secretaries, 92 Webster Park, West Newton, Mass. 02165

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The Carter administration has called on our **Herb Hansell** to be the head of the Law Division of the State Department. He was chosen by Secretary of State Cyrus Vance who has known Herb over the years, the two having worked together on some legal matters and some Yale alumni affairs. Herb is in charge of 65 attorneys, most of them in Washington. He and his staff must review the many decisions, agreements, contracts, proposals, and negotiations made daily on subjects as diverse as nuclear matters and domestic legislation. Herb hopes to learn the job quickly, as there is a great deal to learn. Herb leaves the Cleveland law firm of Jones, Day, Reavis-Pogue, a firm that has provided other members to work with previous administrations. Herb's wife, Jeanne, and their three children will be moving to Washington in June after Jeanne has completed her job as Director of the aftercare program at Fairhill Psychiatric Hospital in Cleveland. Since leaving M.I.T., Herb earned his law degree at Yale and practiced law in New York City, before joining the National Science Foundation in Washington. In 1953 he joined the Jones, Day, Reavis-Pogue firm and became a full partner in 1960. Herb has worked on the Council on World Affairs Legal Aid Society, Cleveland Bar Foundation, and the Shaker Heights School Board. We wish the best of success and happiness to Herb and Jeanne in their new life.

Dr. **Ernest Jaworski** has been elected member Board of Trustees, Gordon Research Conferences, Inc., and the editorial board of Annual Reviews, Inc. . . . **Lewis T. Mann, Jr.**, is only partially retired. He is teaching chemistry for $1.00 per year at California State University, Fresno.

The spring meeting of the M.I.T. Corporation was held on March 30, 1977, and three classmates were elected to positions: secretary is **Donald E. Robinson**, and new directors are **Don E. Burke** and Capt. Stanley H. Rice. — **Russell K. Dostal**, Secretary, 18837 Palm Cir. Cleveland, Ohio 44126

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From the clipping services we note that **Jordan Baruch** was nominated by President Carter to the post of Assistant Secretary of Commerce for Science and Technology. . . . We also note that **Claude Brenner**, in his involvement with the New England Council as Assistant Director, is active in the promotion of solar energy. Apparently there is more sunshine in New England than I remember?

Peter Callejas is now appraising environmental engineering projects for World Bank loans for Eastern Africa and supervising the implementation of successful projects. . . . **Robert Blount** is Director, Undersea and Strategic Warfare Development Division, Office of the Chief of Naval Operations with the Navy Department in Washington. . . . **Ruth Morton Mileson** advises that she has been in Kansas City for the last three years and would like to hear from anyone finding themselves in that vicinity. . . . **Stan Landgraf** has been sent to England by McDonnell Douglas for a two-year stint as Chief Resident to Hawton Siddeley. Hopefully will have more next month. — **Dick O'Donnell**, Secretary, 28516 Lincoln, Bay Village, Ohio 44140

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I am writing this month's column at the Parnass Hotel in Zermatt, Switzerland. The Matterhorn juts up for 3,000 ft. above its visible base and creates a visual effect that I have not seen in any other mountain area. Without a handy 500 ft. building or other object on the sheer face of the Matterhorn, my estimates of the height above me have been low by a factor of about two. The sky is clear and skiing excellent on the Theodul glacier which flows next to the Matterhorn. I completed the first tenth of the climb on the Matterhorn going from Zermatt to Furi, and now look forward to climbing the remainder.

Bob Bliss writes to offer help at our 30th Reunion. Bob was one of the drivers who trailed a Tech dinghy to our 15th at the Belmont. Bob is still sailing his Grumman aluminum combi. Bob reports that the Leadership Campaign "poured on the steam" to reach $112.5 million by April 22. Midwest classmates working on the campaign with Bob are: (in Chicago) **Dennis Allegretti**, head of Allegretti, Newitt, Witcoff, and McAndrews; **John Kaymen**, Sales Manager, U.S. Steel; **Warren King**, Principal, Warren King Associates; **Mitch Silverstein,** President of Specialloy; **Bill Weisz,** President of Motorola; (in Detroit) **John Weil**, Vice President, Bendix; Lyndon Welch, S.M. '48, President, Eberle M. Smith Associates; (in Rochester) **Al Murrer**, President of Gleason Works; **William Halblieb**, Professor of Mechanical Engineering, Rochester Institute of Technology; (in St. Louis) **Thomas O. McNearney**, Chairman, St. Louis Federal Savings and Loan; **Donald Atwood**, General Manager, Delco Electronics Division of General Motors.

Bendix Corp. elected **John Weil** Senior Vice President with responsibilities for several staffs including material, manufacturing, and management information systems. John has served as Vice President and Chief Technical Officer of Bendix since 1974.

Dick Berry and his wife, Louise, were awarded the 1977 Civic Achievement Award by the Killingly-Brooklyn, Conn., Chamber of Commerce. They are the first couple to receive the award. Dick is Vice-President of the Research and Development Division of Rogers Corp. Louise is Guidance Director at the Brooklyn school. Their activities include Dick's membership on the Connecticut State Board for Regional Community Colleges, and Louise's membership on the Killingly Board of Education. From 1973-75, Louise served as a State Senator.

William H. Bertolet has been elected regional Vice President of the American Association for Textile Chemists and Colorists. Bill is President and Treasurer of Laurel Products Corp. in Philadelphia, producer of textile chemical speciality products for the textile and paper industries.

Ken Brock has been appointed Vice President for Development and Public Affairs of the Institute of International Education. Ken's Office will be 809 United Nations Plaza in New York City. After 14 years at M.I.T., Ken is joining the volunteers who support M.I.T. After talking to Ken, I'll report more details of his new opportunity.

John M. Clifford survived the Blizzard of '77 in Buffalo, N.Y., by reading *Technology Review*.

Hugh Boyd Morrison died on February 21, 1977. He received his bachelor degree in Course X-A in 1948 and M.S. in 1949. Hugh was Chief Engineer of Rhodia, Inc., in New Brunswick, N.J., and resided at Sycamore Lane in Skillman, N.J. He is survived by his wife, Marian A. Boyd; a son, Hugh Boyd, Jr., 10 years old; and a daughter, Elizabeth DeTrude, 8 years old. On behalf of our classmates, we extend our sympathy to the family of our deceased classmate.

Memorial contributions by family and friends to M.I.T.'s Anita Porell Krause ('48) Memorial Fund are being applied to the purchase of a dual chamber carbon dioxide incubator for use by M.I.T. Professor Paul Gottlieb (above) and his staff in the Immunology Laboratory of the M.I.T. Center for Cancer Research.

The M.I.T. Club of Tampa Bay held its spring meeting at St. Petersburg on March 30. The M.I.T. Logarhythms presented a delightful program. **Gene Purdum, Jr.**, was elected Vice President of the Club. Also in Florida, the Second Florida Festival at Orlando included the following classmates: **Charles Colgan**, **George Wayne**, **Russell C. Law, Jr.**, **Perry Nies**, **Peter Hand**, and **Gene Purdum**.

Bob Dean and **T.H. Pigford** have been elected to the National Academy of Engineering. Bob has made contributions to the theory and reduction to practice in the field of mechanical design of fluid machinery. . . . **Harold Hollister**'s grain farm is still prospering as a hunting paradise stocked with ringneck pheasants.

Bernard M. Gordon, Chairman of the Board and Chief Executive Officer of Analogic Corp. was the recipient of the 1976 Charles S. Draper Outstanding Tutorial Award for his paper entitled "Analog to Digital Conversion, A Tutorial." The Aerospace Industries Division of the Instrument Society of America makes this award to honor the best tutorial lecturer of the annual International Instrumentation Symposium.

John Twomey was a candidate for school committee on the Winchester, Mass., town election in March. John made major contributions to fiscal responsibility in school budgets. He has also worked to provide maximum educational opportunities for the students of Winchester. John charged the Winchester School Committee with neglecting its prime responsibilities for setting educational policy and monitoring the effectiveness of the implementation of the educational programs in the various schools. He believes that the task of youth is to prepare for life; that in the argument over whether preparations should be aimed at equipping our youth to achieve or to adjust, the prime duty of the educational system is on the side of achievement.

Arthur T. White retired from the U.S. Navy in August, 1974. Since that time he has held the position of Manager, Quality Assurance and Safety with the Atlantic Richfield Hanford Co. in Richland, Wash., where A.R.H.C.O. is a prime contractor to E.R.D.A. in defense waste management activities.

Walter Lowrie received the Space Systems Award from the American Institute of Aeronautics and Astronautics at the 15th Aerospace Sciences meeting. Walter is Vice President, Technical

Several hundred M.I.T. colleagues and alumni came together early in June to wish Frederick G. Lehmann, '51, well in his new career as Director of Development at Boston University. The picture shows Fred and Betty Lehmann opening the gift which expressed the affection in which they're held by all those attending — a glass sculpture of the M.I.T. mascot.

Fred Lehmann Moves to Boston University

Frederick G. Lehmann, '51, who's familiar to hundreds — perhaps thousands — of alumni as a "man from Cambridge," has ended an 18-year career at M.I.T. by moving across the river to take on a major new assignment as Director of Development at Boston University.

Mr. Lehmann's new job is to organize and then operate a comprehensive fund-raising activity for the fourth largest independent university in the U.S. He's optimistic about the job and its importance: "The continuity and growth of independent higher education in the U.S. are essential to our future success as a nation," he says in B.U.'s announcement.

Mr. Lehmann's academic work at M.I.T. was in chemical engineering and industrial relations, but he deserted those fields in 1959 to return to the Institute as Assistant Secretary of the Alumni Association. For four years as Assistant Secretary and more than a decade as Secretary, Mr. Lehmann was in charge of day-to-day operations in Cambridge — record-keeping, clubs, and management.

Since 1973 Mr. Lehmann has been Financial Vice President of the Association and Director of the Alumni Fund — a four-year period in which the financial management of the Association has been more closely correlated with that of the Institute and in which the annual Alumni Fund has grown from a level of about $3 million to well over $4 million. It's now considered one of the nation's leading alumni fund-raising efforts.

Operations, Martin Marietta Corp. Denver division. The award is presented to recognize outstanding achievements in the field of systems analysis, design, and implementation, as applied to spacecraft and launch vehicle technology. Walter's citation reads, "For eminent program and technical leadership in successfully designing, developing, and landing two sophisticated Viking spacecraft on the planet Mars. This outstanding achievement in spacecraft systems analysis, design, and implementation yielded the most complex spacecraft ever developed in the free world."

Mike Kami writes that after ten years of "retirement" from I.B.M. and Xerox he finds it impossible to remain inactive. His consulting activities have gradually increased. Lately he has traveled internationally, advising governments and corporations on the economy and the "new economics." Mike's book, *Manual of Management Assumptions for Planning Business Strategies*, third edition, will be published this fall. Mike and his wife, Kay, have many visitors at their serene Lighthouse Point in Florida. — **S. Martin Billett**, 16 Greenwood Ave., Barrington, R.I. 02806

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There are only two more years until our 30th reunion. I wonder if there is still time for Sonya and me to resign as Chairpersons. No matter, we will have an organizing meeting shortly and you can expect a communication toward the end of the summer asking about your reunion-going proclivities and fantasies.

Ronald L. Greene writes that he decided to formulate his own energy policy and left Lockheed last April to work in San Jose for the Nuclear Energy Systems Division of General Electric. . . . He enjoyed a dinner visit with **Woody Rowles, Jr.**, '49, who was out West on business. . . . **Donn F. Pennell** was recently named President of the McNair Realty Company; he retired from the Naval Reserve. "Of five children, our girl will be married in June; we have two boys now in college and two still in high school."

News about **Gerald Grott** and his soujourn in the salt mines comes via a note and newspaper article from the *Arizona Republic* forwarded by Joe Buswell, Class of '31. Gerry sells the salt that must be removed to make room for underground storage caverns for liquid propane and butane gas, 30 million gallons worth, to keep industry in Phoenix going during natural gas cut-offs. The two activities complement each other economically and physically, and appear to be working out very well. Southwest sells salt for use in water softeners and cattle feed, has recently introduced bagged water-softener salt to sell at retail and expects to enter the table salt market next year.

I recently discovered that **William S. Edgerly**, Chairman of the Board and President of State Street Bank and Trust Co., is scheduled to speak at the M.I.T. Club of Boston luncheon on June 9 on "Boston as an International Financial Center." . . . **Andy (A.W.) Bigus** reports on his latest article, "Portfolio Management with Graham and Dodd," in the spring issue of the *Journal of Portfolio Management*. Andy shows that using a conservative security evaluation system over the past 25 years beat the Dow Jones Industrial Average by 9.2 per cent per year for the entire period. Where were you 25 years ago, Andy? Best wishes to all. — **Frank T. Hulswit**, Secretary, 77 Temple Rd., Concord, Mass. 01742

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John B. Ingold is Manager of the Precision Dynamics Division of the Barber-Colman Co., engaged in the design and manufacture of controls for diesel engines and steam and gas turbines. John tells us he is married to a Dutch girl and that he is active in many other international activities, as well. . . . We regret to announce the death of **Franklin G. Fagan, Jr.**, on March 16.

Bob Wohler has recently been appointed Department Manager of Central Chemical Engineering at Polaroid, with responsibility for large chemical engineering projects. He is also involved with the 128 Branch of the M.I.T. Boston Club which has started a series of successful luncheons at Hillcrest Hall in Waltham this year. . . . On February 23, Corning Glass Works in Corning, N.Y., announced the appointment of **Charles J. Lucy** to International Manager and Legal Liaison, Telecommunication Products Department, Corning Electronics. Charles joined Corning in 1952 and, since last year, has served as Technical Manager for Telecommunication Products.

Thomas C. Buchanan has been elected Vice President by the Board of Directors of the Milford Rivet and Machine Co. in Milford, Conn. Tom is responsible for marketing policies, planning and administration for the rivets, rivet-setting machines and coldheaded parts manufactured by the company's divisions in Milford, Elyria, Ohio, Fullerton, Calif., Hatboro, Penn., and, beginning this fall, Greenville, Miss. He has been with Milford Rivet for 25 years. He is an acknowledged authority on riveted assembly methods and is the author of numerous articles and papers on rivets and riveting equipment. Tom lives in Orange, Conn., with his wife, Margaret. — **John T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd., Bedford, Mass. 01730

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Dear 1953-ers: the countdown begins; only 12 months (as of this writing) until our 25th Class Reunion. For those of you who would like to help out in organizing and running the "show", please contact **Dick Lindstrom** in the Boston area, **Will Spring** in the New York area, or myself (at the address below). We *do* need help — as well as your 25th Reunion gifts.

Howie Martin has just joined Mobay Chemical Corp. (in Pittsburgh) as Manager of the Inorganic Department in the Industrial Chemicals Division. Prior to this job change, Howie was Senior Vice President for Kay-Fries Chemicals, Inc., having earlier held numerous senior positions with Cabot Corp. (Howie completed his M.B.A. at Harvard following graduation from the Institute.) . . . **Stephen Kliment** recently came out with a new book, *Creative Communications for a Successful Design Practice*, and is coordinator for a forthcoming continuing education program at Harvard on "Communications for the Design Professional." He is a registered architect, writer and editor in New York City and is author of *Planning City Hall, Neighborhood Conservation* and *Into the Mainstream*. . . . **Dick Mandel** is now President of Trailer Corp. of American and has been elected trustee of the village of Glencoe, Ill. . . . **Gardner Perry** reports, "Getting an M.B.A. degree from the University of Washington — June 1977. Have to get a job now."

Robert Colton is currently Program Manager at the National Science Foundation; one of his major functions is to run the National Innovation Center Experiment (one of the centers is located at M.I.T.). His wife Janie recently earned her M.S.W. from Catholic University and his eldest of three sons will enter M.I.T. as a freshman this fall. . . . **Ben Coe** reports that he is "going into [his] fourth year as Executor. Director of New York State's Tug Hill Commission. The first part of our job culminated in February '76 with a report, "The Tug Hill Region - Preparing for the Future". Now our job is providing support for an experimental land use program for this 1.3 million acre rural area. The Tug Hill approach involves groups of towns with similar interests forming cooperative planning boards. The Commission provides community organization and technical help. In this way regional planning is being done successfully with all decision making at the local level." . . . **Bruce Murray** just published an interesting article, "Are We Going to Rule Our Own Technology — Or Will We Be Ruled by It?", in *Engineering and Science*. Principally, it is a well done piece on the past, present and future effects of technological development on our society (broadly construed); some considerable attention is devoted to energy

problems and the associated transition difficulties. . . . All for now. — **Martin Wohl**, Secretary, 7520 Carriage Lane, Pittsburgh, Penn. 15221

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Gix Lavendan Ubel is awaiting fall when son Andrew will enter M.I.T., becoming the third generation to attend the Institute. Andy's grandfather, Pete Lavendan, was Class of 1920. How many other classmates have children entering Tech? Let us know.

Larry Holmes is beginning a year of sabbatical leave from the University of Western Ontario and is eagerly looking forward to a time dovoted fully to research and writing. His recent book, *Claude Bernard and Animal Chemistry* (Harvard Press, 1974), received a Pfizer Prize for the best book in the history of science published that year.

Ezra Ehrenkrantz was honored by the Building Research Advisory Board of the National Research Council as one who has made outstanding contributions to the building community and the science of building through invention and innovation. . . . **Carl Schmid** is an industrial engineer at the U.S. Postal Service's Lancaster, Penn. Management Sectional Center and admits to being a "part-time farmer."

Looking forward to hearing news of your activities so we can have longer newsy columns in the fall. — **Dave Howes**, Secretary, Box 66, Carlisle, Mass. 01741; Assistant Secretaries: **Chuck Masison**, 76 Spellman Rd., Westwood, Mass. 02090; **Lou Mahoney**, 6 Danby Rd., Stoneham, Mass. 02180

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As we reach mid-year, we appear to be becalmed at sea and in serious straits (ugh!) for want of information from out there. I may have to belabor you with additional puns, or, at the least, commence an instant lottery in this space to excite some interest. Ah well, on to the few who have favored us with comment:

Joyce Davis is working as an attorney for Con Edison in New York while, at the same time, serving as an Adjunct Associate Professor of Radiological and Health Sciences at Manhattan College, teaching a course in nuclear reactor science. Not one to loaf, Joyce has also served Tech as an Educational Counselor in Westchester County, N.Y. . . . **George Goepfert**, a former classmate in Course X, reports that he has returned to Houston after completing a five-year stint in Tokyo for Exxon. George observes that he is enjoying both life in Houston and his new position as corporate planning and financial operations manager with Esso Eastern.

John Morris Dixon, editor of the magazine *Progressive Architecture* in Stamford, Conn., has been elected to the College of Fellows of the American Institute of Architects. John, one of the few Fellows ever elected for achievements in architectural journalism, began his writing career at *Progressive Architecture* in 1960. In 1965 he became a senior editor of *Architectural Forum*, and returned to *Progressive Architecture* as editor in 1971. He is a member of the M.I.T. Corporation Visiting Committee for the Department of Architecture and Planning and has lectured at Trinity College, U.C.L.A., Lawrence Institute of Technology, the Smithsonian Institution, and the Institute for Architecture and Urban Studies. John's wife Carol teaches art at Greenwich Academy and exhibits as a member of several area art associations. Their children, Peter and Susannah, are high school and junior high school students, respectively.

Jean Montagu has forwarded the program notes for "Lovelight," the "first laser drama." The three-act laser production was produced at the Charles Hayden Planetarium, Museum of Science, Boston, by Interscan of Cambridge. The technical director and technical concept for the performance is credited to one Jean "Coco" Montagu. Kudos, and let me know when the show comes to the Big Apple.

Enjoy your summer and please drop us a line if you have a chance. Otherwise, we may have to convert this space to assorted (sordid?) I.E.E.E. notes. — Co-secretaries: **Marc S. Gross**, 3 Franklin Court, Ardsley, N.Y. 10502 and **Allan C. Schell**, 19 Wedgemere Ave., Winchester, Mass. 01890

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We recently phoned several of our classmates in the D.C. area to discover some interesting applications of the M.I.T. '56 education. **David Seidman** returned a few months ago to his career position with the District local government where he is involved with the transfer of technology to city government applications. Dave just completed a three-year assignment to the National Science Foundation under the Intergovernment Personnel Act., whereby federal, state and local governments and universities exchange senior personnel. At N.S.F. he was a manager in the Urban Technology Program, where he was responsible for funding and monitoring several projects at M.I.T. Dave received his Ph.D. in Operations Research from Case, and worked at H.E.W. before joining the District government staff about seven years ago. He and Barrie have two children. During his N.S.F. assignment he met **Wolf Vieth**, who is Head of the Chemical Engineering Department at Rutgers University.

Walter Lawson completed his M.I.T. Ph.D. in Metallurgy before joining the U.S. Army in research and development 15 years ago. He's currently working on night vision projects at Ft. Belvoir — just in case the next war is after dark. He has three children in college, with a daughter following his profession at Carnegie-Mellon. . . . **Reverdy Wright** is also a U.S. Army civilian, as manager of the Computer Center at the Radford (Va.) Arsenal. He did his Ph.D. at the University of Florida, and taught computer science at V.P.I. for three years before moving to his present position. They live in Blacksburg, Va., with three daughters.

Robert Meyer has been with T.R.W. for 15 years — in several positions in California, and is now in their D.C. area office and living in Vienna, Va. . . . **Rusty Schweickart** is at N.A.S.A. Headquarters in D.C., in the Space Shuttle Payload Office. (Perhaps he's the one to see about a ride into orbit!) He's still one of our most healthy classmates, having completed a 450-mile bike tour of Nova Scotia last summer.

Ernest Wolff is on the Technical Staff of the Aerospace Corp., in charge of their Dimensional Stability Laboratory (resisting the conversion to metric?). . . . Axel Rosenblad, '57, has been president of Rosenblad Corp since 1968, which is active in pollution abatement and energy conservation for the pulp and paper industry. He and Patricia have two boys age 14 and 16. . . . **John Frishett**, Lt. Col. U.S.A.F., recently became a command systems manager at Andrews Air Force Base, following completion of the Defense Systems Management College. He earned his Ph.D. at U.C.L.A. in 1971. — **Bruce B. Bredehoft**, Secretary, 3 Knollwood Dr., Dover, Mass. 02030; **Warren G. Briggs**, Secretary, 33 Bancroft Rd., Wellesley Hills, Mass. 02131. Telephone: (617) 235-7436

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From an M.I.T. press release on **Larry Young**'s activities, we learn that N.A.S.A. has chosen his experimental program on motion sickness and weightlessness to be aboard the first Spacelab flight in 1980. Larry is Director of the Man-Vehicle Laboratory at the Institute, and he heads a team of American and Canadian scientists and engineers who've been working for several years to understand human orientation systems. The central question for the Spacelab experiment: how does the human sensory motor system reorganize itself when one of the channels through which it receives information is inoperative because of zero gravity?

Jordan Gruzen, who's Chief Executive of Gruzen and Partners, New York, Washington, and

Jordan Gruzen, '57

Newark, has been elected to the College of Fellows of the American Institute of Architects; he was inducted in June at the annual A.I.A. convention in San Diego. Jordan joined Kelly and Gruzen after graduating from M.I.T. — it was the predecessor of the present firm, founded by his father B. Sumner Gruzen (M.I.T.'26), and Jordan's interest in housing helped earn his firm's reputation as a leader in high-density housing design. Now Jordan is at work on a new town in Iran and (with Skidmore Owings and Merrill) the U.S. Embassy in Moscow. His earlier work includes the Hyatt Regency in New York, buildings at the State University of New York at Stony Brook, the Federal Correctional Center in New York City, and the Schomburg Plaza Apartments, New York City, which won the Bard Award of the City Club of New York and the New York State Association of Architects/A.I.A. Award.

Nelson Disco writes, "In March, 1975, I was elected to a three-year term as Selectman of Merrimack, N.H. (pop. 16,000), and am currently serving my term and working for Sanders Associates in Nashua, N.H." . . . And finally for this month some notes from the dust cover of a novel by **Tolly Kizilos**, entitled *Dwarf's Legacy*: "The setting is the nightmarish city of Neropolis. The Company of Friends controls the action, using games, rituals, rumors, and friendly persuasion. Absolute Freedom is the new religion in this Reconstituted Golden Era. So chaos is institutionalized; promises are taboo; history is 'taught' with happenings. And there is no dissent. People want to cast out the past, forget Dwarf 'who reminds them of authority, father, death.' Besides, Dwarf is dead, or so everyone believes . . ." The accompanying biographical sketch notes that Tolly (his full name is Apostolos P.) is "multidimensional, has five patents, does reviews for the *Minneapolis Tribune*, is a noted lecturer and one of the country's foremost research scientists." — **Fred L. Morefield**, Secretary, Apt. 6A, 285 Riverside Dr., New York, N.Y., 10025

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Strolling along Boylston Street on a sunny day in May, I saw **Ed Jones**, whom I had not seen for several years. Ed, now a Professor of Physics at the University of Nebraska, was in Boston for a brief business visit. Marilyn and Ed now have two sons, ages 8 and 3, and are enjoying the "good, clean Nebraska air." . . . I also had dinner recently with Beth and **Al Russell**, whose son David will be entering M.I.T. as a freshman this fall. Al, a Professor of Mechanical Engineering at the University of Massachusetts in Amherst, visits Boston frequently on consulting assignments for the Environmental Protection Agency. Al also reports that **Joel Schulman** is alive and well and living in New York City where he works for IBM.

At TRW Data Systems in San Diego, **Bruce Walker** has been named Manager of Product Planning for the Retail Systems Division. . . . **Fredrick Gray** is a Senior Engineer at Douglas Aircraft, responsible for propulsion controls development. He is also attending graduate courses in applied science at the Free Enterprise Institute in Los Angeles. . . . **Robert Parente** has accepted a new position as Senior Associate with Theodore Barry and Associates, management consultants in Los Angeles. Bob's activities will focus primarily on the energy area. . . . **Jim Tillman** returned in November from a five-month's

stay at Jet Propulsion Laboratory as a member of the Viking Mars Lander Meteorology Science Team. According to Jim, "the weather on Mars is becoming more interesting, a northeaster passed after an uneventful summer, and data from a complete annual cycle is expected from both landers."

Ken Whipple, who has been with Ford Motor Co. since graduation, is now Vice President-Finance, and in charge of all finance and insurance operations. Ken also recruits at the M.I.T. Sloan School for all Ford finance functions worldwide. Dennise and Ken now have seven children ranging in age from 1 to 22. . . . **Stephen Friedman**, after ten years of commercial and corporate banking, has joined the International Department of Chase. As Vice President, International Department Credit Review Officer, he manages a small group devoted to credit policy, control and administration. . . . Although he is still Executive Director of Wang Laboratories Swap User's Society, **Jason Taylor** has found time to write and publish *The Calculus With Analytic Geometry Handbook*. Published in May, 1976 and reprinted in February, 1977, the book is widely used in schools and universities. Jason urges, "if you have $2.95, try it." . . . **Lee Freese** has been elected Vice President of Freese and Nichols, Inc. in Fort Worth, Tex., one of the state's oldest consulting engineering firms. Lee joined the firm in 1958. He has become very active in civic activities — president of the Fort Worth Opera Association, and member of the Board of Directors of St. Joseph's Hospital.

Paul Rothschild has a new assignment as Vice President and Technical Director, Plastic Products Division of Owens, Illinois, Inc. In this capacity, Paul is responsible for directing all technical areas of the Division. His previous post involved corporate level research and development in plastics, paper and the life sciences. . . . **Greg Lazarchik** was named Manager of Organic Chemicals for the Industrial Chemical Department of PPG Industries' Chemical Division. He had been a Product Manager in PPG's Organic Chemicals Business Group since 1971. Earlier positions included Development Coordinator in the Corporate Development Department and Technical Representative for the Division's Marketing Research Department. . . . **Stan Klein** is now Editor-in-Chief of *Mini-Micro Systems Magazine* in Hudson, Mass.

Unofficial returns from an underwhelming response indicate that the preferred location for our 20th reunion is off-campus at the Harborview Inn on Martha's Vineyard. More details on reunion plans will start flowing your way in the fall. In the meantime, have a happy summer. — **Michael E. Brose**, Secretary, 30 Dartmouth St., Boston, Mass. 02116

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Two major sources of news to catch up on this month. From a variety of newspaper clippings and press releases: **Roger Travis**, President of Medi, Inc., a manufacturer of disposable medical products in Holbrook, Mass., has been elected President of the Smaller Business Association of New England. . . . **Lawrence Roberts**, President of Telenet Communications Corporation in Washington, since 1973, was promoted to Chairman of the Board. Prior to joining Telenet, he was Director of Information Processing Techniques of the Advanced Research Projects Agency of the Department of Defense. . . . **Andrew DeStena** has been elected a Divisional Vice President of Foster Wheeler Energy Corporation. Andrew, who lives in Houston with his wife and five children, has been with Foster Wheeler since graduation. . . . From a short squib in Aviation Week, we note that **Kent Kresa** has been appointed Vice President and General Manager of Northrup's Ventura Division in Newbury Park, Calif. How about some additional info, Kent?

Moving towards the East, Joslyn Manufacturing and Supply in Chicago announced the appointment of **Carlton Gebhart** as Division Manager — Product Engineering of the Hardware Division. . . . **John Poduska**, one of the founders of Prime Computer of Framingham, Mass., in 1972, has been appointed Vice President of Research and Development. Prior to the formation of Prime Computer, John was with NASA-ERC in Cambridge, and was a Ford post-doctoral fellow in electrical engineering at the Institute.

From a recent review of the chemistry department of the University of Massachusetts at Boston, we noted that two of the 14 faculty members are Class of 1959! **Daniel Laufer** is with the organic chemistry group and **Thomas Margulis** is with the physical chemistry group.

The mailbag to the Alumni Fund brought notes from **Charles Baker**, with Aerospace Corporation since 1968, who describes himself as, "stumbling forward as a graying bachelor," and **Steve Spooner**, with the Metallurgy Department at Georgia Tech since 1965. Steve, who also consults with Oak Ridge National Laboratory, visited the Institute last summer with his wife, Betsy, and their son and daughter. As to the passage of time, Steve noted that, while they do row occasionally in the Atlanta area, "I would now sink any respectable shell!"

Finally, Technology Day registration showed **David Dayton** and **Del Delventhal**, who had previously written from Central Connecticut State College, where he teaches math, that he was coming. Unfortunately, our paths did not cross that day. However, the 1959 luncheon table was represented by **Ron Stone**, **Brad Bates** and his family visiting from Detroit, and me. Later that day, I met **Dick Krock** at the Metallurgy Department Party. Dick is with P.R. Mallory in Burlington, Mass., where he has been since completing his doctorate at the Institute. The passage of Technology Day, 1977, reminds me that in two short years we shall be joining together for our 20th. I know that our Reunion Chairman, **Arthur Collias**, has a busy summer scheduled, but we will probably start our planning next fall.

A good summer wish for all. If you have a few moments, why not drop a line to **Phil Richardson**, 180 Riverside Dr., N.Y. 10024, **John Amrein**, 770 Greenwood Ave., Glencoe, Ill. 60022, **Adul Pinsuvana**, A.S.E.A.N. Secretariat, 6 Jalan Taman Pejambon, Jakarta, Indonesia, **Bob Muh**, 907 Chantilly Rd, Los Angeles, Calif. 90024, or myself, **Allan Bufferd**, 8 Whitney Rd, Newtonville, Mass. 02160

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Major **George Meyers** earned a distinctive service ribbon as chief of the communications program division at the Pentagon with the 2044th Communications Group. . . . **George Hixson** has been named senior engineer/manager of LSI Electronics Development at IBM's Federal Systems Division facility in Owego, N.Y. George joined IBM in Owego in 1964 and has held several engineering assignments involving memory development programs and a variety of technologies. . . . **Harry Wolf**, president of Wolf Associates of Charlotte, N.Y., and Tulsa, has been elected to the College of Fellows of the American Institute of Architects. He is a director of the Mint Museum of Art and the Central Charlotte Association, and he is a former chairman of the Charlotte Chamber of Commerce.

During 1976, **John Beckett** took a partial leave of absence from his position as president of the R. W. Beckett Corp. to serve as president of Intercessors for America, an interdenominational Christian group coordinating prayer for America and its leaders. . . . **Gerald Kaiz** has left the N.U.S. Corporation with two co-workers to form a new corporation in Rockville, Md. The Industrial Training Corporation offers a range of training services for skilled and semi-skilled workers using color videotaped programs. — **Robert F. Stengel**, Secretary, 152 Oxbow Rd., Wayland, Mass. 01778

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June. Time is slipping by very quickly this year. Seems like only yesterday we were reading about record cold spells and snows, and now we are into the summer! Of course, here in California the major weather news is our drought. Speaking as a class secretary, I haven't had any drought of news items this year. There has been a fairly steady stream of alumni fund envelopes, news releases, and even a few letters of one sort or another. This month is no exception, and so, without further ado . . . .

Frank Verlot writes that he has moved to Los Altos from Sunnyvale, Calif. The Verlots bought an older house and are fixing it up. They have many do-it-yourself projects under way, including ridding the house of "roof rats" — common in their "rural" area.

Jim Evans is still on the staff at Lincoln Labs and is living in Lexington, Mass. For the past six years he has been involved in studies and meetings related to the choice of a new international civil aviation navigation aid for final approach and landing. The long hours were offset by the opportunity for worldwide travel and the technical challenges of an interesting problem. Jim's wife, Ilse, is a German instructor at M.I.T., so the Evanses have lots of M.I.T. contact.

Bob Edelson brings us up to date on happenings in his family since his last envelope communique. He and his wife, Sue, now have three children in their brood with the birth of their first son, Joseph Myles, last June. Daughters Sara and Jennifer are bearing up under the onslaught. Bob has a couple of new jobs at the Jet Propulsion Lab. He is now Manager, Advanced Projects, for the Deep Space Network, assisting in preparing our capabilities for the space missions of the 1980s. In addition he is Project Manager for our fledgling Search for Extraterrestial Intelligence, preparing to look for signals from outer space. Sounds like a fascinating endeavor!

David Kelly received his Ph.D. in Business Administration last year from the University of North Carolina, and is presently a Senior Research Scientist at the Georgia Tech. Engineering Experiment Station. His recent work has been in the field of economic analyses of wind energy studies by electric utilities.

Short Notes: **John Addis** is still single after all these years and is still designing high-speed vertical amplifiers for Tektronix oscilloscopes. He recently returned from his second trip to the U.S.S.R. . . . Another classmate, **George Bryant** is active in local government. George is chairman of the board of selectmen of Provincetown, Mass. . . . **J.F. McDonald** is currently Associate Professor at Rensselaer Polytechnic Institute, Troy, N.Y., in the Electrical Engineering Department. . . . Back at the Institute — M.I.T., that is — **Eric Cosman** has been promoted to full professor in the Physics Department. Eric has been on the staff and faculty since receiving his Ph.D. in 1966. He is active in the field of nuclear physics. . . .**Fred Cunningham** and **Sandy Lensch Cunningham** are the proud parents of a son — Michael Eliot, born April 26 of this year. Congratulations.

Enjoy your summers, and drop me a line to let me know what you're doing. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

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About four months ago, I began to hear about the San Francisco drought. More recently the Potomac River basin was measured at dangerously low drought levels. But now I really know what drought is — no news from classmates. This column will exhaust all saved, held over, and otherwise available class news in hand at this time. Enough said?

Donna and **Ralph Bestock** are pleased to announce the birth of thier "first child on March 2, 1977, a beautiful little girl. Her name is Laurel Diane." We're sure she is beautiful, and good luck to the three of you.

Robert L. Muhr reports that his new position is Salary Administration Officer for U.C.S.B. (as best I can make out the letters). He and his wife, Joan, have two kids.

For all of you who save your *Technology Reviews*, go back two issues for the beginning of

Jim Lerner's letter. Here's the rest: Jim's been with the California Energy Commission since July, 1975. His work is in solar energy implementation. As part of an overall solar mobilization plan, Jim has been emphasizing the need for research and development in the wind energy area. (He recommends the January, 1977, issue of *Technology Review* for an article on wind energy.) The goals are ten 2-megawatt prototypes by 1980 to 1981, and five 100-megawatts on-line in California by 1985. On the personal side, Jim often dreams of returning to the Greek Islands (which he plans to do someday), but he can't seem to put more than a few days off in a row together at present. Jim isn't married but he has a special lady in his life (his "significant other"). Her name is Judy, and aside from such important credentials as coming from a small town in N. Louisiana (Jim's from Shreveport), she is a speech pathologist who teaches at a city elementary school. Her students are children with speech and language difficulties; her work is very demanding but very rewarding.

As for me, Marlene is starting to establish our "roots" in the area; her initial move has been redecorating the downstairs of our home, a sure sign of planned geographical longevity (even though we moved just after doing the house over in Massachusetts). I have taken up the fun sport of racquet ball; when all the walls, the ceiling, and the floor count, you get a lot more action between serves. Later this month, we're all heading up to Ogunquit, Maine, for a couple of weeks — first long vacation (for me) in two and a half years and I'm especially looking forward to it, but I'm not alone in my anticipation. That's all for now. — **Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, Md. 20854

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Nice letter from **John Golden**; late in 1975 John left Polaroid and the Boston area to join Schering-Plough as Director, Corporate Information Processing. As such, he is responsible for worldwide data center and technical support activities for the pharmaceutical manufacturer, including computer sites at Kenilworth, N.J.; Memphis, Tenn.; Lucerne, Switzerland and Paris, France. When not flying to one of these spots, Jon lives in Summit, N.J., with wife Carolyn and their four children — Lisa (11), Jenni (9), John (7), and Matthew (3).

The rest of the news comes from the backs of Alumni Fund envelopes and news clippings. **Stephen Dangel** writes that in November, 1976, he married Paula Shindell; they are living in Cambridge while house hunting. Steve is still with Millipore, heading a group that designs production equipment.

Ellen and **Aaron Goldberg** live in Framingham with daughters, Deborah (4) and Laura (1). Aaron is a section leader at G.T.E. Sylvania's Electronic Systems Group, Needham, Mass. He is developing speech digitization equipment using microprocessors.

The most exotic news this month is about **David Kettner**, who began working in August, 1975, at Lincoln Lab Project Press at Kwajalein, Marshall Islands, far away in the South Pacific. In July, 1976, Dave was promoted to Section Leader and was appointed Associate Justice for the Kwajalein Community Court by the Trust Territory of the Pacific. David reports that he is enjoying photography, scuba, diving and sailing.

Joseph Ladish went from Tech to Yale for a Ph.D. in physics and is now working on lasers at the Los Alamos Scientific Laboratories. Claire and Joseph live in Los Alamos, N. Mex., with children, Christine (12) and Matthew (10). . . . **George Roman**, president of his own architectural firm, recently spoke at the Wellesley Rotary Club on energy concerns in the design of new buildings.

That's it for this month. Hopefully the long summer hiatus and reunion will bring more news for fall. Y'all write. — **Edward P. Hoffer**, M.D., Secretary, 12 Upland Rd, Wellesley, Mass. 02181

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Ed Graham writes that he is still an assistant professor at the Sloan School. Ed married the former Mary Francis Freed on November 27 of last year. He reports their future plans are indefinite and that he is thinking of going to Washington, given the right opportunity. . . . **Calixto Romero** is now in private practice, cardiology, in Denison, Tex. Previously, he had been director of the Cardiacath Lab at the U.S. V.A. hospital in San Juan, Puerto Rico. . . . **Roger Rasmussen** became the father of twins — Paul and Carolyn — on September 3, 1976. Roger is with the Rand Corp. and his work there is split between education and health care research. . . . **Richard Gray** writes that he will be moving from Marblehead to Brookline this summer. . . . **Bob Atkins** is still enjoying life in the Shenandoah Valley of Virginia. He is looking forward to having a "university teaching position" in the near future as Madison College has changed its name to James Madison University.

John Adger reports that **Tom Jones** ran into an old friend of John's wife on a recent trip to the Virgin Islands. John talked with Tom and looks forward to seeing him when he gets to Washington. . . . Union College reported that **Dave Hayes** has been awarded an $8,000 grant by the Research Corp. to study the way enzymes catalyze biochemical reactions. Dave is an assistant professor of chemistry at Union. . . . **Bob Pindyck** coauthored an article in the spring issue of *The Public Interest*. Among other things, the article suggested that the U.S. must eliminate all price controls on oil and natural gas.

Stu Vidockler is the administrator of "Lovelight, A Laser Musical," which is currently playing in Cambridge. We look forward with great anticipation to its appearance on Broadway. . . . Also on the entertainment front, yesterday I received a letter from **David Liroff**, who recently moved from Athens, Ohio, to St. Louis to assume a position as Director of Programming of public television station KETC-TV/Channel 9. David is wondering about the whereabouts of Charlie Gitomer, '65. So, the call goes out — Charlie Gitomer where are you? — **Paul Rudovsky**, Secretary, 340 E. 64 St., New York, N.Y. 10021

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Dave Schramm was recently promoted to full professor in the departments of Astronomy and Astrophysics at the Enrico Fermi Institute and the College of the University of Chicago. He currently serves as acting chairman of the department of Astronomy and Astrophysics. . . . Joanie and **John Fittz** recently welcomed the arrival of their second child, Kristie. They are quite challenged with "Here's Life, America" developments throughout New England as representatives of the Lay Ministry of Campus Crusade for Christ. They are working closely with pastors and lay leaders of all denominations in this effort. . . . **John Robinson** is in the cardiography marketing group at Hewlett Packard's Medical Electronics Division in Waltham, Mass.

Steve Berger is employed in the Optical Systems Division of I.T.E.K. Corporation in Lexington, Mass. . . . After five years service in the Air Force, **Herbert Schulze** made the break and returned to civilian life. He is now clerking for United States Judge Howard Turrentine in San Diego. The cases in their court run from electronics patent lawsuits to civil rights to laetrile to bankruptcy. Herbert and Anita are expecting their second child in June. . . . **Dale Crane** is the manager of research and development in the Laser Products Division of Spectra-Physics, Inc. . . . **Jon Sussman** has returned to Massachusetts, as Engineering Manager for Test Equipment Manufacturing of Digital Equipment Corporation. Jon, Margie, and their daughters, Jami, 7, and Karen, 4, are living in Framingham. . . . **Dick Gauthier** married fellow Stanford psychology graduate student Emily Bassman last June. Upon receiving his Ph.D. in the area of pattern recognition, Dick plans to teach and do research for Renaissance Universal, a young organization exploring the integration of personal and social development within a broad humanistic-spiritual and technological perspective. . . . **Alan Perelson** is working in a theoretical biology and biophysics group at Los Alamos Scientific Laboratory on theoretical problems in immunology and carcinogenesis. His wife Jan is a second-year law student at the University of New Mexico. . . . **Barbara Desmond Gilchrest** completed training in dermatology last year and is now studying the effect of ultraviolet light on the aging of human skin. — **Jim Swanson**, Secretary, 669 Glen Rd., Danville, Calif. 94526

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Denis Coleman writes from Hawaii. After receiving a Ph.D. from Stanford, Denis taught at York University in Toronto. Correctly predicting last winter's mini-ice age, he accepted a position as an assistant professor at the College of Business of the University of Hawaii, Honolulu: "Since they don't play hockey here, my spare time is spent at jogging, tennis, golf, and other Hawaiian sports. I encourage my vacationing classmates to call me at U. H." . . . **Rick** and **Karla Karash** announce the birth of the first child, Ann Theresa, on April 5. Karla has taken a short leave from her job as an Assistant Secretary at the Massachusetts Executive Office of Transportation and will return part-time in July and full-time in September. Rick is working as a vice president with Management Decision Systems, a marketing consulting firm in Weston. . . . Louise ('71) and **Jerry Grochow** have moved to Chicago as a result of Jerry's promotion to vice president and head of American Management Systems' Chicago office. Louise has a new position as a Senior Resident at the University of Chicago, Billings Hospital. . . . **Karen Brothers** is quite busy with Consultus (the computer service company she shares with **Louise Silver**), her children's school activities, and a large vegetable garden. . . . **Claude Gerstle** is in private practice in ophthamology now, recently bought a horse, and has three children. . . . **Bob Roach** has taken a job with Mathematica, Inc., in New York, as a consultant to promote and apply their data management package, RAMIS. . . . **Ron Rosen** is still with Shared Educational Computer Systems, working on a mixture of hardware and software problems. His wife, Marilyn, is now a staff programmer for IBM. They spend their spare time hiking, square dancing, weaving, and woodworking. . . . **Ken Zwick** is working for Mead Data Central Inc., as a staff attorney in charge of litigation support projects for the east coast. He lives in North Wales, Penn., a suburb of Philadelphia.

We look forward to seeing all of you at the tenth reunion next June in Boston. Start planning now. — **Gail** and **Mike Marcus**, Secretaries, 2207 Reddfield Dr., Falls Church, Va. 22043

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Hello, sports fans. Here's the news. Lula and **Roger Chang**, of Columbia, Md., announce the birth of their second son, Michael James, on February 24, 1977. The Chang's first son, Daniel, is almost 5 years old. Roger left the Army on May 15, 1977, to become a principal engineer for the Computer Sciences Corp. . . . **Dave Kelleher** is doing systems analysis and applications development for I.B.M. in Waltham, Mass. His wife Joanne is a postdoc in developmental biology at the Boston Biomedical Research Institute.

Charles Bieger has completed his doctoral disseration in molecular biology at U.C.L.A. and is now at Scripps Clinic in San Diego for postdoctoral work.

Mitchell Wand has been named Associate Professor of Computer Science at Indiana University. His wife Barbara is attending law school at Indiana and is on the law review. Their daughter Rebecca was 3 this year.

Richard A. Parker expected to receive his Ph.D. in oceanography in May. He intends to stay

in College Station, Tex., as a coordinator for the Bureau of Land Management. His wife Sue, and sons Joel and Jeremy, are reportedly happy to return to normal family life with only the children in school. . . . **Burt S. Barnow** has resigned as an assistant professor of economics at the University of Pittsburgh to accept a position with the U.S. Department of Labor in Washington, D.C. . . . **Josette C. Goldish** and her husband Louis, '67, are living in Newton, Mass., with their children Andy (5) and Suzy (2). Josette is working part time with Walden Research Division of Abcor in Wilmington, Mass.

Ken Horner has been working as a management consultant for Touche Ross in Detroit for the past four years. Ken and his wife Barbara are off for an extended stay of 18 months in New Zealand, where he will be handling an engagement for the New Zealand Department of Health and Hospitals. . . . **David C. Hill** is Assistant Director of Research for the Linde Division of Union Carbide, Tarrytown Laboratory, Tarrytown, N.Y. His wife Rosanne was expecting in May. . . . **Mike Henning** and his wife Harriet are expecting their second child any day now (that was back in April). Mike is teaching high school.

Hans W. Polzer has left the Army after a four-year tour in Stuttgart, Germany. He is working for Operating Systems, Inc. in Arlington, Va., as a system engineer and project manager. . . . **Robert J. (Sandy) Randall** is living happily in Groton, Conn., with his wife Donna and sons Chris (4) and Tim (2). He is superintendent of steel trades at the electric boat division of General Dynamics. He has earned his P.E. license in N.Y. and Conn. and is also a structural consultant. He sails the Xinker II.

That's it, friends. — **Peter Peckarsky**, Secretary, 950 25th St. NW, Washington, D.C. 20037

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Leslie Tung has been selected to receive a Ph.D. fellowship from the Health Sciences fund for a theoretical and experimental study of the electrophysiology of injury potentials arising in cardiac muscle. . . . **Doug Hough** received his Ph.D. in economics from the University of Wisconsin, Madison. His dissertation, "The Economics of the Market for Human Blood," will be published by Lexington Books of D.C. Heath Co. (soon to be a major motion picture — so Doug says). . . . **Nancy Liebman Rosenfield** and her husband Don, '69, are living in Bedford. Don is a consultant with Arthur D. Little and Nancy has just joined Data Resources in Lexington as a senior programmer. Their daughter Hennifer will be 3 this summer.

Donald T. Black will marry Jean Ellen Thomson (Wellesley, '73) in West Chester, Penn., and will live in Manhattan where Donald works as a patent attorney. . . . **Ben Roberts** has been active: he married Judith Anne Higgins (Vassar, '68) on June 7, 1975; received a degree from Stanford University in civil engineering; has just returned from an 18-month assignment in Manila (the Philippines), designing improvements to the city's water system and is returning to Stanford to work on his Ph.D. in civil engineering. . . . **Lester Byington** has been with the Pomona Divison of General Dynamics working on the design of guidance and control computers for a variety of tactical missiles. He now has an engineering staff position, responsible for long-range planning of digital processing design. He has been mountaineering in the Sierras, (Mexico and Argentina) and cycling in the local mountains.

Richard Goldberg graduated from Caltech in June with a Ph.D. in physics. After a vacation in Europe, he began work at Bell Laboratories in network planning. . . . **Andrew Lippman** is a research assistant for the Architecture Machine Group, which studies interactive computer graphics. He married Annie Harris of Lexington, Mass., an architect and city planner, who is a vice president of the Crownshied Corp. in Peabody, Mass., which specializes in adopting buildings for re-use.

Mike Gilmore begins a world tour in September. After departing from the East Coast he will go to western Europe, Kenya, then to India, Thailand, Singapore, Hong Kong, Taiwan and Japan. He would like to get Christmas cards from anyone addressed to him at the Milimani Hotel, Nairobi, Kenya. We all should be so unfortunate. . . . **Marc Barman** has some exciting news: he and his wife Joyce have had their first baby — Julie, born on March 17 . . . Congratulations . . . Marc writes, "I'm working in product development at Hewlett-Packard's General Systems Division, which is so full of M.I.T. grads it is like old home week. I may never leave California. The Bay area has everything you could ever want (except water). I particularly enjoy having an orange tree in my back yard."

I left Brenham last weekend for a canoe trip down the rapids of the Guadalupe River. I assumed it was going to be an easy trek, but after my fourth spill out of the canoe, I decided it was not so easy. We only covered about 18 miles each day but had a great time. Texas has a lot to offer. Please write. — **Hal Moorman,** Secretary, P.O. Box 1808, Brenham (which is near Houston), Tex. 77833

72

Bob Goodof writes, "I've survived another winter of facing rubber pucks in the hinterlands of Central Michigan. I was in Plastics New Product research and development until my present assignment in Economic Forecasting and Financial Services — one of those 'learn while you earn' plans. We're looking to start an outstate Michigan M.I.T. alumni club. Anyone interested?"

Wendy Erb reports, "I'm working hard (naturally) as a Park Avenue attorney. It can't really be that school's over. I'm glad to have the winter bar exam behind me, so now I'm enjoying New York's theater, dance, and museums. My roommates and I have started running in Central Park daily to prevent the spread so many lawyers develop. I saw **Kathy Kram Dobkin** in New Haven. She's working on her Ph.D. and going to California for the summer. **Joe Edwards** was here at a meeting to recruit freshmen in his role as head of the Educational Council. I'm off to Africa after the reunion in June."

Gail Thurmond has one more year of residency in internal medicine at the University of Tennessee, followed by a residency in neurology at Dartmouth. . . . **Roger Flood**, who has been at the Wood's Hole Oceanographic Institute, has been awarded a N.A.T.O. fellowship for study at the National Environmental Research Council in Somerset, England. . . . Julio Monjes is working as an engineer in the Lawrence Livermore Lab in the laser fusion program, where he is permanently engaged in the design supervision of the target chamber target positioner, target alignment optics, and laser beam focusing system for the 20 beams 20 T.W. Shiva Laser experiment. — **Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

73

Greetings once again from your rusty (excuse me, that's trusty) correspondent. The volume of mail has diminished to a fathomable amount, so we're able to get it all in. **Scott Davidson** finished an M.S. and has moved to the University of Southwestern Louisiana for a Ph.D. He sees lots of former M.I.T. Science Fiction Society people at Illinois, where he received his master's degree. . . . **Tom Stagliano** is finishing an E.A. at Tech and has become a professional soccer referee. He organized and co-captains a team playing in a Massachusetts industrial league. "Wish all my friends a good summer. Come see us play if you get the chance."

Ed Fenstermacher married a high school classmate, Carol Jacobson, in June, 1976. At the same time, he got out of the Air Force and is enrolled in his second semester at Maryland, studying nuclear engineering. . . . **Jay Anderson** is in grad school at Illinois, expecting a Ph.D. in physics in late 1978. His group is one of the few studying lasers operating in nuclear reactors rather than electrically. He is married to the former Sandy Lufti (M.Ed., Illinois, '74). . . . **Mark Liss** will begin interning at Mt. Sinai Hospital in New York City.

John Breen is living in Greece, N.Y., and soon moving to Henrietta, N.Y. He is married now four years to his wife Wendy. Currently, John is employed as a camera design engineer for Kodak, designing instant cameras. . . . **David Simen** of Ruddigore-ghostly fame is wondering why he received no *Tech Reviews* for six months.

Yours anorexially has, at long last, met the girl of my dreams on a recent trip home to Durham, N.C. This time it's the real thing. I know it. I know it. I think I know it. More to come, no doubt, when I discover if she can see fit to put up with — **Robert M. O. Sutton**, Secretary, 37 Fairbanks St., Brighton, Mass. 02135

76

I had a pleasant surprise while shopping at Filene's. There, I met **Bob Aaronson**, who is an assistant buyer of men's clothing. For a while after graduation, he was driving a cab, and found it educational but not well paying. He is enjoying working at Filene's a lot more.

Mark Crane married Barbara Ann Wilson, '77, on June 4. Our congratulations to both of them. Mark, who is a student at Sloan, suggested something I would like to pass on to you. A number of us studied with Hans Lucas Teuber in 9.00 or in seminars. Mark suggested that we start on a fund to support new faculty in Course 9 in memory of Professor Teuber. Your comments and suggestions on this would be greatly appreciated.

From the mails, I have learned that **Philip Comeau** has been appointed to the faculty of the Berklee College of Music. Phil was in the Festival Jazz Ensemble under Herb Pomeroy while at the 'Tute. . . . A brief note from **Harvey Simkovits** indicates that he is completing his M.S. at M.I.T. in electrical engineering.

Gordon Fulton writes that he is "just about to complete my first year as a communications engineer with Shell Oil, and I've enjoyed it. Engineering and supporting a data communications network exposes a person to the entire system — software and hardware. We're getting into 'smart multiplexors' as of late last year." I wonder what a multiplexor is? Will someone send news and diminish my ignorance a wee bit?

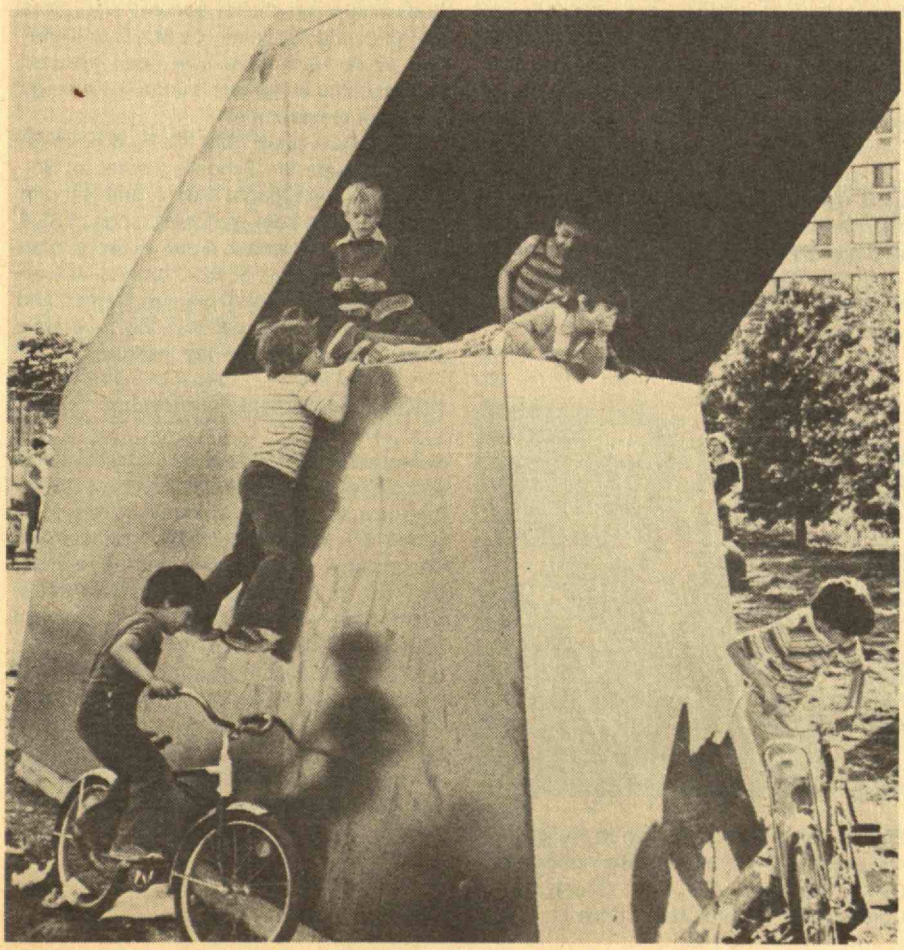
Douglas Finn writes that he spent last year bumming around Europe and is now working for Canadair in Montreal. He is doing aeroelastic engineering for the "Challenger" corporate jet program.

While attending a party hosted by, among others, Arlie Sterling '77, I had the pleasure of bumping into a new "informant" who wishes to be known as "Sore Throat"! Sore Throat informs me that **Peter Gergen**, **Jerry Kazin**, **Reynold Lee**, **Sue Riedel**, and **Maggie DeGasperi** are renting a house together. Peter is doing graduate study in chemistry at Brandeis. Jerry makes guidance systems for missiles at Raytheon. Reynold is working as a programmer for a firm in Kendall Square. Sue is getting an M.S. in Aero and Astro and will be getting a job soon. Maggie is working as a marketing executive for Gillette in its hair dryer division. Sore Throat also told me that **Mike Chepponis** took some time off and is working for the Culver Educational Foundation in Culver, Ind., as a systems analyst and will be coming back in September to complete his studies in electrical engineering. And **Stan Kenney** spent some time traveling in Mexico and Guatemala, and is now working for the Pine St. Inn, a home for derelicts in Boston. Throat also reports that **Terry Allbritton** is a community planner for the North Delta Regional Planning and Development District, Inc., based in Monroe, La. **Bruce Barshefsky** is working for the Mass. Dept. of Youth Services evaluating facilities (jails!) for youths adjudicated delinquent. The job was an outcome of his work in Urban Studies.

My many thanks to Sore Throat. Why don't more of you take some time this summer to write? — **Arthur J. Carp**, Secretary, 67 Badger Cir., Milton, Mass. 02186

The combination sonar and camera in this picture is now deployed in Loch Ness, awaiting its chance to detect and record the elusive "monster." The equipment comes from the laboratory of Harold E. Edgerton, Sc.D.'31, Institute Professor, Emeritus, at M.I.T., who turned it over — as this picture was made — to Charles W. Wyckoff, '41 (left), owner of Applied Photo Services, Inc., who's associated with Robert H. Rines, '42, in the search. (Photo: Calvin Campbell)

Future Fiestas of the M.I.T. Club of Mexico City will be celebrated with this banner, an official gift of the Alumni Association to salute the 30th Fiesta in Merida early this year. The banner is displayed by Edward O. Vetter, '42, President of the Alumni Association, and William M. Collins, '65 (right), Vice President of the Club, while Raymond H. Danon, '58 (back to camera), President of the Club, speaks its thanks during the Fiesta's closing luncheon. (Photo: Ronald S. Stone, '59)



A monumental 11-ton fire-engine-red steel sculpture by Tony Smith called "For Marjorie" was dedicated this spring. It looms near Tang Hall at the west end of M.I.T.'s campus, forming what looks like a large archway to the Westgate residential complex. The 18-foot-tall piece is dedicated to a close family friend of the Smiths, Marjorie Eisman. The original model for the sculpture was a gift to her from Mr. Smith in 1961.

D. H. Darden

J. V. Evans

D. C. MacLellan

H. W. Slotkin

state, data systems, seismology, and space research and Mr. MacLellan for work in satellite communications and energy programs.

☐ **Helen Willa Slotkin,** formerly Head of the Special Collections Department of the University of Cincinnati Libraries, is now Institute Archivist in the M.I.T. Libraries; she succeeds Professor E. Neal Hartley who retires this summer after holding the post of Archivist part-time while teaching in the Department of Humanities. Ms. Slotkin trained for library work at Simmons College, and she'll work closely with the M.I.T. Historical Collections under the direction of Warren A. Seamans.

Bronowski, Gropius, and the Bauhaus on the M.I.T. Press Agenda

Four major titles have been contracted by the M.I.T. Press for publication between the end of this year and early in 1981:

☐ A definitive biography of architect Walter Gropius by Reginald Isaacs, Charles Dyer Norton Professor of Regional Planning at Harvard. Publication in the spring of 1978.

☐ *Bauhaus in America* by Hans M. Wingler, a sequel to Mr. Wingler's earlier book, *The Bauhaus*; the new book will be a large-format volume with some 500 illustrations in 650 pages. Publication: 1981.

☐ Two new works by Jacob Bronowski, author of *The Ascent of Man*; they are *A Sense of the Future: Essays in Natural Philosophy* (Fall, 1977) and *The Visionary Eye and the Imaginative Mind: Essays in the Philosophy of Art* (Spring, 1978).

The Symphony Records Barber, Copland

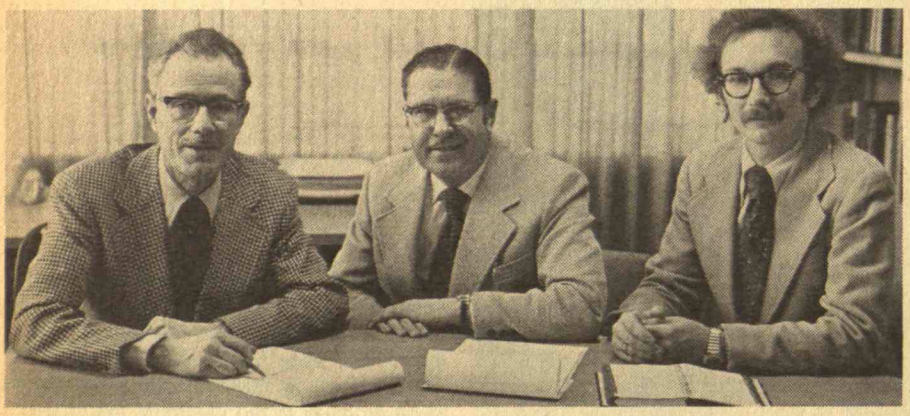
A new record for your collection: The M.I.T. Symphony Orchestra, Professor David Epstein conducting, in piano concertos by Samuel Barber (Opus 38) and Aaron Copland; the soloist is Abbott Ruskin, a prize-winning pianist trained at the Juilliard School of Music.

The recording is the second in a projected series of four discs on the Vox/Turnabout label featuring the M.I.T. group (*see* MIT '77 *for March/April, p. A5*). It's the second recording in history of the Barber concerto — the first was in the mid-1960s by the Cleveland Orchestra under George Szell. The new disc can be ordered at any record store; it's in stock at the Tech Store of the Coop, Building W20, M.I.T., Cambridge, Mass., 02139.

Xerox Joins VI-A

Xerox Corp.'s Palo Alto (Calif.) Research Center has joined the roster of companies participating in Course VI-A, M.I.T.'s cooperative program in electrical engineering, and the first two students have begun work there this summer.

Course VI-A is the largest of several cooperative programs at M.I.T. — 172 students during the Spring Term. There will be 81 job openings at the 17 firms and laboratories in the VI-A program for members of the Class of 1979, and this year John A. Tucker, Director of the Course, had 162 applicants.



Michael D. Schroeder, '73 (right), has a new job at Xerox Corp.'s Palo Alto Research Center: he's Liaison Officer for the M.I.T. students who will work there under the Cooperative Course in Electrical Engineering (VI-A). With him in the picture are George E. Pake (left), Manager of the Center, and John A. Tucker, Director of Course VI-A. (Photo: Xerox Corp.)

Rising Trend of Blood Donors

Every eligible member of Theta Chi and Phi Delta Theta fraternities gave blood in the spring drive for the Boston Chapter of American Red Cross — the first time more than one fraternity has hit 100 per cent. It cost Alpha Phi Omega, the national service fraternity, two kegs of beer instead of the one in the budget.

The total of 1,595 pints given at M.I.T. in one week this spring made it the "second best blood drive in three and a half years," according to Steven Piet, '78. Meanwhile, in a separate drive Lincoln Laboratory employees contributed 246 pints — also ahead of last year.

Saving Energy Worth $1.138 Million

A "cost avoidance" of $1.138 million — which means a saving by M.I.T. of nearly 23 per cent of its nominal energy budget — has earned the Institute a citation from the Federal Energy Administration.

F.E.A. cited seven private colleges and universities for reducing energy consumption as a result of self-initiated energy management programs. The report was prepared by the Association of Physical Plant Administrators of Universities and Colleges with technical support from August L. Hesselschwerdt, Jr., '31, Professor Emeritus of Mechanical Engineering at M.I.T.

Arms Control Research at Harvard

Studies in international security and arms control conducted jointly by M.I.T. and Harvard since 1973 have now been assured major funding in Harvard's John F. Kennedy School of Government.

A $4 million grant from the Ford Foundation will create the School's Center for Science and International Affairs, and Harvard has pledged to seek matching funds of $5.6 million as endowment. Paul M. Doty, Mallinckrodt Professor of Biochemistry at Harvard, will be Director of the new Center, and he has pledged to maintain the program's close connections with the Institute.

$45,000 for Medical Fellowships

Metropolitan Life Insurance Co. will provide $45,000 during the next three years for fellowships to support students in the Harvard-M.I.T. Program in Health Sciences and Technology. The students will be working for Ph.D. or M.D. degrees, and Dr. Paul S. Entmacher, Metropolitan's Vice President and Chief Medical Director, calls the Program — the aim is to prepare physicians with strong backgrounds in engineering or science and to prepare physicists to work in clinical medicine and health care delivery —"an innovative approach to some of the crucial problems in the health care field today."

I
Civil Engineering

Donald C. Taylor, S.M. '56, is now Director of Research and Development for the Kellog Corporation ... In his career with the U.S. Navy, **William P. Donnelly,** S.M. '68, has served as Head of Engineering Department, Pacific Division, Naval Facilities Engineering; Director of Construction, U.S. Contracts, Laos; and most recently, as an Instructor in the Mechanical Engineering Department at the U.S. Naval Academy ... **Guy Dufresne,** S.M. '65, is Vice President —Marketing, Pulp and Paper for Consolidated Bathurst, a large forest products company headquartered in Montreal ... Congregation Beth Pinchas in Brookline, Mass., has elected **Norman Kram,** S.M. '73, as its new president. The congregation is the synagogue wing of the New England Chassidic Center ... **Kenneth L. Recker,** S.M. '73, has been promoted to Project Engineer for the firm of Haley and Aldrich, Inc., Cambridge, Mass.

II
Mechanical Engineering

The Illinois Institute of Ecology's Professional Achievement Award for this year went to **James P. Hartnett,** S.M. '48, Director of the Energy Resources Center of the University of Illinois at Chicago Circle. He was selected for his "outstanding contributions to his chosen field of endeaver." ... **F. Carter Karins,** S.M. '65, is a Director of the M.I.T. Club of Tampa Bay, Fla. ... **Charles A. Yoerkie, Jr.,** S.M. '70, has completed the Ph.D. degree in the area of applied mechanics from the University of Connecticut ... **Vinay K. Nagpal,** S.M. '69, is Manager, Technical Services, for Control Components, Inc., in Irvine, Calif. The firm manufactures and designs low noise flow control valves.

III
Materials Science

The Spring 1977 issue of *Electronic Progress,* published by the Raytheon Company, Lexington, Mass., includes the article "Meeting New Materials Challenges," by **C. B. Willingham, Jr.,** Sc.D. '66, and **R. L. Gentilman,** '70 ... **Robert Mainhardt,** '48, is President and Chairman of the Board of M.B. Associates ... **Adelaide T. Sundin,** '47, is working as a ceramic artist involved in portraiture in Parian Porcelain.

IV
Architecture

The Building Research Advisory Board of the National Research Council honored **Robert Newman,** M.Arch. '49, with one of their Building Sciences and Construction Technology Awards. The award, in the category of Professional Development, is for "outstanding contributions to professional development in design, planning, engineering, programming, research, testing, teaching, law, economics, regulation, government service, etc." ... **Craig D. Roney,** M.Arch. '71, has been working as an architect in Rome, Italy, for two years ... **Virendra K. Girdhar,** M.Arch. '67, has been named as associate by Gruzen and Partners, New York, Newark and Washington ... **Robert Eastwood McConnell,** M.Arch. '54, is one of 56 new members in the College of Fellows of the American Institute of Architects. He is professor and dean of the University of Arizona College of Architecture, and has been named to *Who's Who in America.*

V
Chemistry

The Pharmaceutical Manufacturers Association has elected **Gerald D. Laubach,** Ph.D. '50, to the position of Chairman of the Board. He is President of Pfizer, Inc. ... **Anestis L. Logothetis,** Ph.D. '58, is presently Division Head in charge of research on "Viton" type fluoroelastomers, at the DuPont Experimental Station in Wilmington, Del.

Arthur M. Poskanzer, Ph.D. '57, will be Chairman of the Division of Nuclear Chemistry and Technology of the American Chemical Society; he was also recently elected a Fellow of the American Physical Society ... **Stephen H. Fairheller,** Ph.D. '64, has been appointed Chief of the Hides and Leather Laboratory at the Eastern Regional Research Center of the U.S. Department of Agriculture's Agricultural Research Service in the Philadelphia area.

VI
Electrical Engineering

Kenneth N. Stevens, Sc.D. '52, Professor of Electrical and Bioengineering in the Department of Electrical Engineering and Computer Science at M.I.T., has been appointed to the department's Charles Joseph LeBel Audio Engineering Professorship ... **Leroy V. Sutter, Jr.,** S.M. '73, received his Ph.D. from U.C.L.A. this year and is now working at Hughes Aircraft Company, Culver City, Calif., as a member of the technical staff.

William Hogan at Lowell: New Priorities for a New Vice President

W. T. Hogan

As Dean of Engineering at the University of Lowell (it used to be Lowell Technological Institute and now has become a full-fledged partner in the University of Massachusetts system), William T. Hogan, Sc.D. '65, spent most of his time worrying about how to stretch an inadequate budget to cover equipment needed to teach engineering.

Now he has the same problem for the whole University; "we are very concerned with finances," he said late this winter upon being chosen the University's new Vice President for Academic Affairs.

Other high-priority tasks:

☐ Restructuring the University's administrative system.

☐ Integrating a new computer system into the teaching programs. "We are in an area in Massachusetts known for high computer technology," he said in an interview upon being confirmed by the University's Board of Trustees, "and we are sensitive to our own shortcomings in this field."

☐ Expanding services to the community. "I grew up in Lowell," he said, "and I know what opportunities the University can offer to the area."

Richard Held Is Acting Head

R. M. Held

Professor Richard M. Held, who was closely associated with the work of the late Hans-Lukas Teuber while he was Head of the Psychology Department, has been named Acting Head of the Department. Professor Teuber was lost and presumably drowned in a swimming accident off Virgin Gorda in the British Virgin Islands early this year.

Dr. Held, who is Professor of Experimental Psychology, is known as an authority in the field of perception. He has been at M.I.T. since 1963, having studied civil engineering at Columbia University (B.S. 1944) and psychology at Swarthmore (M.A. 1948) and Harvard (Ph.D. 1952); he was a member of the faculty at Brandeis University from 1953 to 1962 and of the Institute for Advanced Study at Princeton in 1955-56.

LeBel Audio Professorship

K. N. Stevens

In 1968 the late Clarence J. LeBel, '27, established a Professorship in Audio Engineering at M.I.T., and now Kenneth N. Stevens, Ph.D. '52, Professor of Electrical and Bioengineering, has been honored by appointment to it.

A founder of the Audio Engineering Society, Mr. LeBel was its President in 1958. Dr. Stevens has just completed a one-year term as President of the Acoustical Society of America. He's a recognized expert in acoustics and speech communications, having joined the faculty in 1954 after two years on the research staff of the M.I.T. Acoustics Laboratory.

Bridging the Engineer-Physician Gap

A two-year grant of $150,000 from the Henry J. Kaiser Family Foundation will help the Harvard-M.I.T. Program in the Health Sciences develop a new curriculum in medical engineering and medical physics. Dr. Robert J. Glaser, President of the Foundation, said his Trustees "recognize the need to bridge gaps in understanding between engineers and physicians jointly involved in incorporating advanced technology into health care systems."

Polymer Processing, Chemical Systems

The Chemical Engineering Department will use a new $234,000 grant from the National Science Foundation to strengthen teaching and research in polymer processing and chemical engineering systems. Under the direction of Clark K. Colton, Ph.D. '69, there will be new equipment, new graduate subjects in the polymer field, new research programs, a series of seminars, and an improved reference library.

It's part of a larger, on-going effort to strengthen the Department's graduate training and research, according to Professor Kenneth A. Smith, '58, Acting Head.

Current issues and developments in computers and communications were reviewed by a team of experts for 17 key government officials late last winter in a seminar series designed by Alexander J. Tachmindji, S.M. '51, Vice President of MITRE Corp.'s Metrek Division. The picture shows Mr. Tachmindji with his keynote speaker, former Senator Vance Hartke (right) who, during his Senate tenure, was Chairman of the Subcommittee on Communications. (Photo: Thomas L. Williams from MITRE *Matters)*

VI

Paul M. Pan, S.M. '46, Chief Scientist and Research and Development Manager for the Westinghouse Defense and Electronic Systems Center, has been awarded the corporation's highest honor, the Westinghouse Order of Merit . . . The May, 1977 issue of the *Bell Laboratories Record* features an article on "Integrated Circuit Testing" by Mark R. Barber and **Alfred Zacharias,** E.E. '55. The article explains how recent testing developments make it possible for large-scale integrated circuits to come off the production line and be tested in about five seconds . . . **D. D. Clark,** Ph.D. '73, gave a talk recently on "A High-Speed Local Computer Network" . . . A new course, "Data Compression Techniques," has been developed by **Thomas J. Lynch,** M.S. '59, for the George Washington University Continuing Engineering Program.

Honors from I.E.E.E.

Eighteen members of the M.I.T. community were honored last month by the Institute of Electrical and Electronics Engineers on the eve of its 1977 annual convention in New York.

President **Jerome B. Wiesner** headed the list as recipient of I.E.E.E.'s Founders Medal "for leadership and service to the nation and engineering and scientific professions in matters of technical developments, public policy, and education."

Robert M. Fano, '41, Ford Professor of Engineering, received I.E.E.E.'s Education Medal "for leadership in engineering education through teaching and outstanding research in computer science, information theory, and electromagnetic theory."

The Browder J. Thompson Prize, including a $1,000 honorarium, given for the best paper by an author under 30 published in an I.E.E.E. publication, was handed to **Michael R. Portnoff,** '71, who is now a graduate student at M.I.T. Mr. Portnoff's paper: "Implementation of the Digital Phase Vocoder Using the Fast Fourier Transform," published in *I.E.E.E. Transactions on Acoustics, Speech, and Signal Processing* for June, 1976.

Ivan A. Getting, '33, President and Director of Aerospace Corp., became President-Elect of I.E.E.E.; he'll serve the Institute as President in 1978.

Fourteen members of the M.I.T. community were elected by I.E.E.E.'s Board of Directors to the grade of Fellow, the Institute's highest membership grade: **Frederick W. Baumann,** S.M. '34, of Scotia, N.Y.; Professor **Jerome R. Cox, Jr.,** '47, of Washington University; **Hisashi Kobayashi,** S.M. '72, of I.B.M. Corp., Yorktown Heights, N.Y.; **Ernest R. Kretzmer,** Sc.D. '49, of Bell Telephone Laboratories; **Alexander Kusko,** Sc.D. '51, Lecturer at M.I.T.; Professor **James R. Melcher,** Ph.D. '62, of M.I.T.; **Samuel Noodleman,** '37, of Inland Motor Division, Blacksburg, Va.; Professor **Alan V. Oppenheim,** '59, of M.I.T.; Professor **Richard H. Pantell,** '49, of Stanford University; Professor **Ronald W. Schafer,** Ph.D. '68, of Georgia Institute of Technology; Professor **William F. Schreiber** of M.I.T.; Professor **Fred C. Schweppe** of M.I.T.; Professor **Thomas G. Stockham, Jr.,** '55, of the University of Utah; and Professor **Gerald L. Wilson,** '61, Director of the M.I.T. Electric Power Systems Engineering Laboratory.

VII

Life Sciences

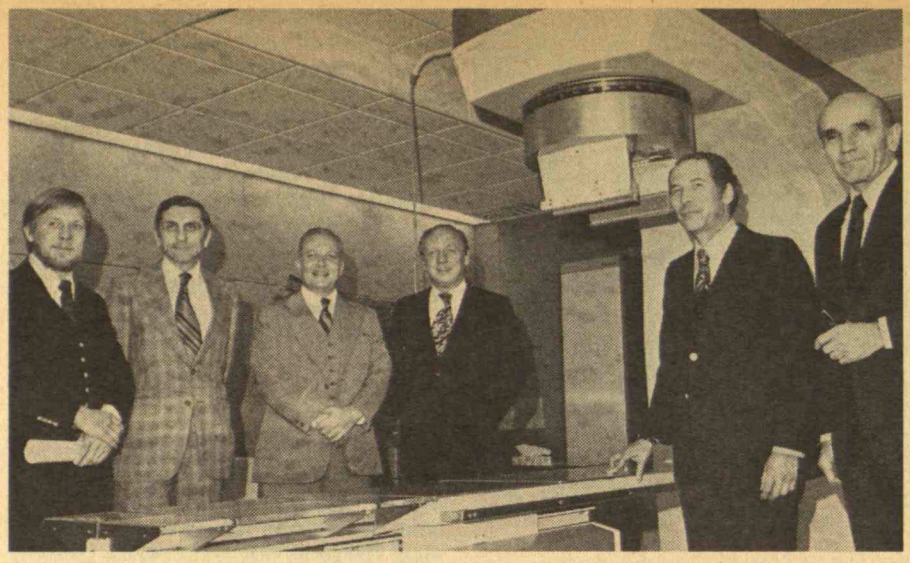
David G. Natyan, Pediatrician-in-Chief of the Sidney Farber Cancer Center and Chief of the Division of Hematology and Oncology of the Children's Hospital Medical Center and Farber Center, is Visiting Professor of Biology for the current year. He's associated with the Harvard-M.I.T. Program in Health Sciences and Technology.

M. E. Kaighn, Ph.D. '62, is a senior research scientist at the Pasadena Foundation for Medical Research collaborating with a group of six urologists for his research in cancer of the prostate supported by the National Prostate Cancer Project. He was formerly a senior scientist at the W. Alton Jones Cell Science Center in Lake Placid, New York . . . **Heber J. R. Stevenson,** '49, attended the M.I.T. Second Florida Festival . . . **David Baltimore,** '62, M.I.T.'s American Cancer Society Professor of Microbiology and 1975 co-recipient of the Nobel Prize in Medicine and Physiology, served as the 1977 Fred J. Robbins Lecturer at Pomona College, Claremont, Calif.

VIII

Physics

Stephen J. Lukasik, Ph.D. '53, a physicist and former Vice President of the Xerox Corporation, has been named Senior Vice President in charge of national security research programs at The Rand Corporation, Santa Monica, Calif. . . . In a debate on nuclear power, called "The Great Nuclear Debate," **Norman C. Rasmussen,** Ph.D. '56, spoke in favor of the further development of nuclear power for the generation of electricity. He heads M.I.T.'s Departent of Nuclear Engineering . . . **Harry Gove,** Ph.D. '50, a member of the University of Rochester faculty since 1963, has been named Chairman of that University's Department of Physics and Astronomy . . . **Martin Jesse Klein,** Ph.D. '48, has been elected to membership in the National Academy of Sciences. Election to Membership in the N.A.S. is considered to be one of the highest honors that can be accorded to an American scientist or engineer. Dr. Klein is the Eugene Higgins Professor at Yale University.



Clinical trials of a new computerized control system for this radiation therapy unit at New England Deaconess Hospital are the responsibility of the Harvard-M.I.T. Program in Health Sciences and Technology; Dr. Irving M. London, Director of the Program, is posed in the picture with Dr. Samuel Hellman, Chairman of the Radiation Therapy Department of Harvard Medical School. The computer controls the accelerator and the movement of the treatment couch, on which the patient lies, to maximize the exposure of malignant cells and minimize that of normal tissue to the high-voltage radiation.

Polymer Processing Mechanics on Video

Thirty-two color videotape lectures and demonstrations on "The Mechanics of Polymer Processing" by Professor J. R. A. Pearson of Imperial College, London, are now available for rent or purchase from the Center for Advanced Engineering Study at M.I.T. There is an accompanying set of three study guides, including lecture notes, problems, and problem solutions, and a textbook.

Of the 32 lectures, eight are considered introductory, suitable for orientation material; later programs on polymer melt mechanics and applications to polymer processing are more analytical and require mathematical background. The series is based on Professor Pearson's studies capitalizing on what he considers the most unusual characteristics of polymers — their mechanical properties which vary with temperature, material and type of deformation.

For further information, write to the Center for Advanced Engineering Study, Room 9-230, M.I.T., Cambridge, Mass., 02139.

Solving the "Missing Sulfur" Problem

Squeezed under the almost inconceivable pressure of 1.6 million atmospheres, iron sulfide changes from one state to another — from its normal density of 4.6 grams per cubic centimeter to an iron-like density of 8.1 grams per cubic centimeter.

Thomas J. Ahrens, '57, Professor of Geophysics at California Institute of Technology who achieved this result in a 108-foot, 30-ton, two-stage gas gun in Caltech's Laboratory of Experimental Geophysics, hypothesizes that this new super-dense iron sulfide solves the "missing sulfur problem: If the solar system has a common origin, how can it be that the sun, moon, and meteorites all contain far more sulfur, proportionately, than can be identified on earth?

Professor Ahrens' hypothesis is that perhaps one-third of the earth's molten core is made up of this extra-dense iron sulfide. This would contain enough sulfur to bring the earth into balance with other solar-system bodies, and it leaves the mass of the core essentially unchanged — still consistent with present astrophysical observations.

Northeast of the Galapagos

John M. Edmond, Associate Professor of Oceanography, and Tanya Atwater, Assistant Professor of Marine Geology, spent much of February and March searching with the research submersible *Alvin* for deep-ocean hot springs on the Galapagos ridge crest, 200 miles northeast of the Galapagos Islands. There was evidence of hydrothermal activity in the region during an expedition of last summer, Professor Edmond says, and 15 to 20 dives with the *Alvin* — the Woods Hole Oceanographic Institution's deep-diving submarine — were planned for the six-week period this winter.

A team from several universities made up the winter expedition; among its members were Robert S. Ballard, '75, of Woods Hole Oceanographic Institution.

A Resounding Vote for Investments to Stimulate the U.S. Economy

Of five alternatives open to President Jimmy Carter for stimulating the U.S. economy this year and next, Robert E. Hall, Ph.D. '67, Professor of Economics at M.I.T., is outspokenly opposed to tax cuts and increased government spending. His macroeconomic model makes clear the virtue of such investment policies as tax credits, employment credit, and monetary expansion, he told a Panel on Economic Activity at the Brookings Institution late last year.

The five alternatives:

☐ A personal income tax reduction, which would almost surely be temporary because of President Carter's announced intention to fund new federal programs beginning in the second year of his administration.

☐ Increasing government expenditures, which Professor Hall calls "the traditional Keynesian remedy for recessions."

☐ Investment tax credit, "the oldest countercyclical tool on the tax side of fiscal policy," which is appealing because of high leverage: "it promises a larger increase in aggregate demand per dollar of revenue foregone," Professor Hall said.

☐ Employment credit, which could be achieved, for example, by a small decrease — temporary or permanent — in the employer's contribution to Social Security.

☐ Monetary expansion, "the quickest and cheapest" countercyclical policy which is of special interest when used "in parallel with fiscal policies."

The first two of these are called expenditure policies. The last three, investment policies, have a "crushing advantage" because they have future leverage on new capital, said Professor Hall. Expenditures at once stimulate investment and inflation, the latter soon "crowding out" the former.

Investment credited has a special advantage, according to Professor Hall's model, because the capital formation it stimulates is available only a year after imposition of the credit, and prices are likely to be actually lower then — an advantage "overlooked in virtually all studies," he said.

Employment credit has three things going for it, according to Professor Hall: "every percentage point of the employment credit is a percentage point reduction in labor cost, which is passed along as a reduction in prices," he said. It attacks the basic problem of unemployment directly. And a permanent employment credit soon enough disappears as wages are renegotiated — "a self-liquidating stimulus," and this feature is its "real attractiveness to the economists."

	Program:			
	Expenditure increase	*Investment credit*	*Employment credit*	*Monetary expansion*
Increase in real gross national product (per cent)				
1977	0.72	0.72	0.85	0.82
1978	0.19	−0.16	−0.19	0.37
1979	−0.03	0.03	0.03	0.46
1980	−0.09	0.09	0.10	0.48
Increase in price level (per cent)				
1977	0.35	0.43	−0.57	0.43
1978	0.68	−0.61	−0.75	−0.14
1979	0.39	−0.39	−0.46	0
1980	0.38	−0.32	−0.38	−0.06
Increase in investment (billions of 1972 dollars)				
1977	−10.5	9.7	11.3	10.8
1978	2.6	−2.2	− 2.6	1.7
1979	− 0.4	0.4	0.5	1.6
1980	− 1.4	1.2	1.5	1.5

This chart shows the effect on gross national product, inflation, and investment of four alternative programs for stimulating the economy according to a macroeconomic model developed by Robert E. Hall, Ph.D. '67, Professor of Economics. The magnitude of each program is that which has the effect of increasing 1977 G.N.P. by about $10 billion (0.8 per cent of the forecast total G.N.P.). Of the three programs that stimulate investment (the right three columns of the chart), "none is clearly superior to the others," Professor Hall said.

Books by two members of the Political Science Department were launched this spring by the M.I.T. Press. The authors are Professor Martha W. Weinberg (center), whose subject is Managing the State, *and Professor Langdon Winner (right), who's associated with the Technology Studies Program and whose book is entitled* Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought. *With the two authors is Walter A. Rosenblith, Provost.*

X
Chemical Engineering

Herbert Kay, S.E. '47, has been named to the new position of Corporate Vice President for Engineering and Technology, at AMAX, Inc., Greenwich, Conn. . . . **David S. Hacker,** S.M. '50, reports that he is presently engaged in theoretical and experimental studies relating to conversion of photon energy to chemical energy via the photocatalysis processes . . . **Larry J. Lilly,** S.M. '65, has been appointed Assistant Superintendent of the Organic Chemicals Division, Tennessee Eastman Company, Kingsport, Tenn. . . . **William L. Bulkley,** S.M. '40, has retired after 30 years of service with the Amoco Oil Company. He was a senior research associate in the Research and Development Department at the Amoco Research Center in Naperville, Ill.

XIV
Economics

Robert M. Solow of M.I.T.'s Department of Economics has been elected as a member of the Council of the National Academy of Sciences. He will be serving a three-year term in this position.

Stanley Fischer, Ph.D. '69, will be promoted to full professor as of July 1. His specialty is monetary theory and economic growth.

Richard S. Eckaus, Ph.D. '53, who is known as an expert on developing countries and their economic problems, is now Ford International Professor of Economics. The Ford chair which he now holds is the result of Ford Foundation support for M.I.T. in the field of international relations; Evsey D. Domar, a specialist in the Russian economy, holds the companion Ford chair.

Professor Eckaus has been a member of the M.I.T. faculty since 1962, and he has specialized in studies of the effects of technologies and technology transfer — and of investments in education — on developing countries.

William D. Nordhaus, Ph.D. '67, Professor of Economics at Yale University and a specialist in the economy of inflation and energy, has been appointed to President Carter's Council of Economic Advisers. . . . **T. Paul Schultz,** Ph.D. '66, Professor of Economic Demography at Yale University, has been appointed to the new Malcolm K. Brachman chair at Yale University.

Warren Bennis, Ph.D. '55, will be resigning effective September 1 from his position as the 18th President of the University of Cincinnati. He said that "five to seven years is an optimum time for the most effective service by a University President. On September 1, I will have served for a period of six years." . . . **John Turnbull,** Ph.D. '47, writes that he has only a few years to go before retiring after more than 30 years of teaching economics at the University of Minnesota.

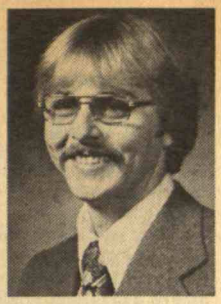
XV
Management

Dale Runge, Ph.D. '76, will return to the Sloan School on July 1 as Assistant Professor of Management. His research interests include labor market policies and economic development modeling, and since graduating in engineering from Dartmouth (B.A. 1964, B.M.E. 1965) he has taught in Valparaiso, Chile, and worked on research at the University of California in Los Angeles and the Automobile Club of Southern California.

Thomas R. Williams, S.M. '54, was elected Chairman of the First National Holding Corp., Atlanta, Ga. . . . **Lee L. Selwyn,** Ph.D. '69, President of Economics and Technology, Inc., Boston, a research and consulting firm specializing in telecommunications and utility regulation, delivered a paper, "Pricing Telecommunications Services: Policy Goals and Rate Design Principles," at the Third Annual Symposium on Problems of Regulated Industries in Kansas City, Mo., in February. . . . **Joseph C. Profita,** S.M. '47, has been appointed to Senior Research Engineer in the Office of International Programs of the Denver Research Institute of the University of Denver. Mr. Profita previously was Chief Technical Adviser and Consultant in marketing and distribution for the International Labor Office of the United Nations; in that position he was assigned to the Management Development and Productivity Institute in Ghana. . . . *Stock Market Strategy* is the recently published book by **Richard A. Crowell,** '62. He is Senior Vice President and Chairman of the Investment Policy Committee of The Boston Co., Inc. . . . **Stan Abraham,** S.M. '68, received a Ph.D. in management from U.C.L.A. in March, 1976, and is now working for the Rand Corp. in Santa Monica. **D. O. Smart,** S.M. '66, writes that his "consulting firm, The Calibre Group, has just become a managing associate for the New York-based Training House, Inc., developers and publishers of training and development systems for supervisors and industrial managers. Calibre has marketing and installation responsibilities in a 12-state area in the Midwest." . . . **Doyle Little,** S.M. '69, writes that he "continues to complete oil and gas wells to provide energy to an increasingly hostile nation of consumers who don't appreciate the problems and costs involved." . . . **Walter Lehmann,** S.M. '75, Market Planning Manager for Stewart Warner Corp., Bridgeport, Conn., was appointed assistant director of the M.I.T. Associates Program, a program founded in 1961 to facilitate the flow of knowledge between the M.I.T. faculty and the industrial community.

T. R. Williams

W. S. Wheeler



J. W. Litchfield

Leroy E. Day, S.M. '60, is deputy director of the Space Shuttle Program at N.A.S.A. headquarters, Washington, D.C. . . . **Eugene J. Eckel,** S.M. '62, has been named Western Electric's vice president of Bell Sales Division-East, Newark, N.J. He will direct organizations responsible for supplies distribution, equipment repair and installation, and telephone system engineering for Bell companies in the eastern U.S. . . . Two new appointments announced by Corning Glass Works: **James G. Kaiser,** S.M. '73, to general manager of sales and marketing for the Consumer Products Division at Sovirel, a subsidiary in France; and **John R. DallePezze,** S.M. '67, to division controller of the Technical Products Division. . . . **William S. Wheeler,** S.M. '54, has been appointed Senior Vice President of the AutoExhaust Catalyst Group, Engelhard Industries Division, of the Engelhard Minerals and Chemicals Corp., Murray Hill, N.J. . . . **Robert E. Smylie,** S.M. '64, has been named Deputy director of N.A.S.A.'s Goddard Space Flight Center in Greenbelt, Md. . . . Wachovia Bank and Trust Co. in Winston-Salem, N.C., has announced the election of **Henry L. Waszkowski,** S.M. '73, to Assistant Vice President. . . . The new manager of the Decision Analysis Section of Battelle's Pacific Northwest Laboratories is **James W. Litchfield,** S.M. '73. He lives in Yakima, Wash. . . . **James W. Darrin,** S.E. '63, of Reading, Mass., is product manager for the American Shoe Machinery Co.

Andrew P. Bergeron, S.M. '69, is Vice President of the Matrix Group, which is a multifaceted firm specializing in financial institution real estate problems . . . **Hervey L. Sweetwood,** S.M. '71, was elected to the Del Mar, Calif., City Council last year. And this year, he had a book published — *Tool for Trainers* . . . The Warner and Swasey Company has named **John H. Hubbard,** S.M. '63, as Vice President and General Manager of its Research Division. He will be responsible for operation of the company's Research Center in Solon, Ohio, where he will be based . . . **R. Clark Harris,** S.M. '72, has been appointed factory manager of Sikorsky Aircraft Division of United Technologies Corp., Stratford, Conn. He had been Manager of Operations Analysis for United Technologies since he joined the corporation last year . . . **James F. Burns,** Ph.D., '67, is Professor of Industrial and Systems Engineering at the University of Florida . . . **Dave Raney,** S.M. '65, is presently serving as Vice Chairman of the Hawaii Citizens' Statewide Forum for Coastal Zone Management, an advisory group consisting of approximately 40 representatives of business, labor, environmental, and community groups . . . **Robert Wall,** S.M. '72, is manager of corporate planning for Raymond International, a worldwide construction firm . . . **John W. Starke,** S.M. '68, has been appointed Director of Corporate Planning of the Government National Mortgage Association (G.N.M.A.). G.N.M.A. is a $40 billion insurance company owned by the Federal Government.

XVI

Aeronautics and Astronautics

John H. Sweeney III, S.M. '60, is currently assigned as Production Officer of the Charleston Naval Shipyard, S.C. . . . **William T. McDonald,** Sc.D. '68, Staff Scientist in the Autonetics Group's Strategic Systems Division of Rockwell International in Anaheim, Calif., was one of 11 engineers who received a Rockwell Engineer of the Year Award. . . . Lieutenant Colonel **Joseph M. Samborsky,** S.M. '63, has retired from the U.S. Air Force at Andrews A.F.B., Md., after more than 20 years of service. . . . **Jacob Wiedhopf,** S.M. '73, worked as an engineer for three years after graduation. He is currently an M.B.A. student at Stanford Business School . . . **Lawrence Levy,** S.M. '48, is executive director of the New England proposal team, a group of individuals who are working to obtain national solar energy laboratory work for New England. **Claude W. Brenner,** '47, is assistant director for this group.

Julio Monjes, S.M. '72, is working as an engineer in the Lawrence Livermore Lab in the laser fusion program where he is permanently engaged in the design supervision of the target chamber target positioner, target alignment optics, and laser beam focusing system for the 20 beam 20 T.W. Shiva Laser experiment . . . **Marc L. Sabin,** Sc.D. '73, has been awarded the Meritorious Service Medal during special ceremonies at the Armed Forces Staff College in Norfolk, Va. He received the award for his outstanding service as Chief of the Applied Mathematics Division and Deputy Director of Aerospace Mechanics Sciences at the Air Force Academy in Colorado Springs, Colo.

XVII

Political Science

Lucian W. Pye, Ford International Professor of Political Science and Senior Staff Member of the Center for International Studies, has been appointed chairman of a committee of the East-West Center in Honolulu, Hawaii, a national educational institution established by Congress in 1960 to promote better relations between the U.S. and the nations of Asia and the Pacific through cooperative study, training, and research.

Edward E. Azar, Professor of Political Science at the University of North Carolina, is part-time Visiting Professor at M.I.T. this term, continuing a part-time appointment held during the first term by **Herbert H. Hyman,** Professor of Sociology at Wesleyan University.

Dr. Hyman is a principal figure in the field of public opinion and political society, and his work on interviewing methods and secondary analysis of public opinion polls is widely known. Dr. Azar's specialty is the analysis of international political problems and cooperation.

Microeconomics Wins for the Sloan School

Joel Stern, President of Chase Financial Policy — a division of Chase Manhattan Bank — thinks that microeconomics should be the basis of all graduate programs in schools of management, and — having made that decision — he rates M.I.T.'s Sloan School and the University of Chicago Business School in "a virtual tie" for the title of "best business school." Chicago's faculty is stronger, but M.I.T.'s students are better, he writes in *MBA* magazine.

Mr. Stern associates microeconomics with "path-breaking theorists and empiricists," and he contrasts such programs with those emphasizing case study, where the faculty is likely to be "dominated by intuitionists."

"If a student learns microeconomics early in his program and applies its principles in the fundamental disciplines . . . his market value will be great, his intellectual needs satisfied, and his inner happiness maximized," Mr. Stern wrote. "M.I.T., Chicago, Berkeley, Rochester, and Stanford are the best places to study now."

U.N.'s Hunger Programme at M.I.T.

The World Hunger Programme, a major activity of the new United Nations University, has moved into temporary offices in M.I.T.'s Building 20 — close under the nose of Dr. Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science who is the Programme's Senior Adviser.

The office will stay at the Institute until W.H.P.'s work is in full operation, when most functions will move to the U.N.U. headquarters in Tokyo; but a small American office will be left behind. W.H.P.'s goal is research and training on nutritional requirements, national planning, and food conservation; there will be workshops and conferences throughout the world.

A New Diet for Cancer Patients

It is a paradox of cancer care that many patients die of malnutrition while they are receiving the most sophisticated chemical and radiation therapy that medical science can provide.

The problem is that both forms of therapy have side effects of nausea and loss of appetite. The typical response has been standard intravenous feeding — and every encouragement for patients to eat.

Now there's a new response being tested by Dr. William P. Steffee, Ph.D. '74, Assistant Professor of Medicine at Boston University who is Director of the Clinical Nutrition Unit at University Hospital, Boston. Under sponsorship of the National Cancer Institute, Dr. Steffee and his associates are substituting an enriched intravenous food called TPN (total parenteral nutrition), and Dr. Steffee is convinced that it "has turned around the whole outlook on nutritional care."

The standard intravenous solution contains only sugar and water. In contrast, TPN is a highly concentrated solution of nutrients — almost ten times as many calories as the equivalent amount of standard solution and enough amino acids to supply 120 grams of protein.

Two problems, which are at the center of Dr. Steffee's research:

— TPN causes complications — infections and occasionally blood clots — in 10 per cent of the patients who receive it. The question is whether these can be controlled, and whether the benefits override this risk.

— Some physicians believe that the nutrients supplied in TPN do more to strengthen the patient's malignant tissue than the healthy tissue, and Dr. Steffee wants to evaluate this judgment.

XVIII
Mathematics

Professor **Gian-Carlo Rota** is the editor of the *Encyclopedia of Mathematics and Its Applications,* published by Addison-Wesley Publishing Co.

Leonard M. Adleman, who has been Instructor in Mathematics this year, has been named Assistant Professor in the field of applied mathematics effective July 1. He holds bachelor's and doctoral degrees (Ph.D. 1976) in computer science from the University of California at Berkeley.

Joel Moses, Ph.D. '67, has been promoted to Full Professor in the Department of Electrical Engineering and Computer Science at M.I.T.

Two alumni have been honored with membership in the National Academy of Engineering: **Stephen H. Crandall,** Ph.D. '46, of M.I.T., for leadership in the theory, education, and practice of engineering mechanics, especially in random vibration analysis; and **Alan J. Perlis,** Ph.D. '50, of Yale University, for innovation on computer languages and compilers and leadership in computer science and engineering. Stephen Crandall is also a lecturer at an international seminar on "Safety of Structures under Dynamic Loading" held in Trondheim, Norway, at the end of June.

John A. Englund, S.M. '51, has been named Executive Vice President of Analytic Services Inc., an independent, nonprofit research corporation which serves the government, primarily the Air Force, located in Falls Church, Va.

XIX
Meteorology

Robert M. White, Sc.D. '49, administrator of the National Oceanic and Atmospheric Administration, will join the National Research Council staff as the Chairman of a new Climate Research Board. The Board is being established to monitor research into climate-change and its causes and effects and to serve as a focal point for climate-related work of the Research Council . . . **Gerald W. Grams,** Ph.D. '66, has been elected a Fellow of the Optical Society of America . . . **Frederick Sanders,** Sc.D. '54, has been elected a councillor of the American Meteorological Society for a three-year term. He is currently a professor of meteorology at M.I.T.

XX
Nutrition and Food Science

Nicholas Catsimpoolas, Associate Professor of Food Biochemistry, is editor of the new book, *Isolectric Focusing,* published by Academic Press.

Gerald N. Wogan, Professor of Toxicology, is one of 30 members of the Clearinghouse on Environmental Carcinogens recently established by the National Cancer Institute.

Anthony J. Sinskey, Sc.D. '67, has been promoted to the rank of full professor in the Department; his special interest is applied microbiology.

Dr. **Noel M. Solomons** will be Assistant Professor of Clinical Nutrition effective July 1. A graduate of Harvard and Harvard Medical School (M.D. 1970), Dr. Solomons interned at the University of Pennsylvania Hospital, and he has taught and practiced in the field of gastroenterology and nutrition at the University of Chicago's Department of Medicine.

Reuben Pomerantz, S.M. '53, has been elected to the Board of Directors of the International Association of Holiday Inns. . . . **W. Davy A. Perera,** Ph.D. '75, left the U.S. after completing his thesis and is now at the Department of Nutrition, Medical Research Institute, Colombo, Sri Lanka. . . . **James Tillotson,** Ph.D. '64, has been promoted to vice president of technical research and development at Ocean Spray Cranberries Inc., Plymouth, Mass. . . . **Arthur E. Humphrey,** S.M. '60, Dean of the College of Engineering at the University of Pennsylvania, is a co-chairman of the conference on Mass Transfer and Scale-Up of Fermentations at New England College, N.H., in July, sponsored by The Engineering Foundation.

Jerry L. Welbourn, S.M. '61, has been named Corporate Research Manager of McCormick & Co. Inc., producers of spices and specialty food products, based in Baltimore, Md.

XXII
Nuclear Engineering

Professor **Norman C. Rasmussen,** head of the department, has been given the distinguished service award of the U.S. Nuclear Regulatory Commission.

Louis S. Scaturro received his Ph.D. from Columbia University at the end of last summer with a thesis in the field of experimental plasma physics, and he has now joined the Department as Assistant Professor. He's in charge of 22.07 — "Preparation for Plasma Physics," the introductory course in fusion processes given primarily for sophomores.

Mujid S. Kazimi, Ph.D. '73, formerly Associate Nuclear Engineer in the Department of Applied Science, Brookhaven National Laboratory, is Assistant Professor; his special fields are nuclear reactor design and safety and technology transfer in developing countries.

Lee N. Price, S. M. '66, became a general partner in the investment firm, Rosenberg Capital Management last January. His second son, Eric Charles, was born in May. . . . **George V. Neill, Jr.,** S. M. '71, was in the U. S. Army Corps of Engineers from June, 1971, to June, 1974, in Vietnam and Fort Riley. Now he is working at General Electric in the Fast Breeder Department working on system modeling, analysis and optimization.

Allan A. Offenberger, Ph.D. '68, has returned from a sabbatical year at the Culham Research Laboratory of the U.K. Atomic Energy Agency, Abingdon, Oxfordshire, to a promotion: Professor of Electrical Engineering at the University of Alberta.

Edward E. Pilat, S.M. '67, has been appointed Vice President of Research for the Energy Research Group, Inc., Framingham, Mass., a private research and consulting firm which performs technical and economic assessments of energy alternatives.

Brian Schultz, S.M. '66, is a Project Engineer for the Stone & Webster Nuclear Power Plant — the first standardized balance-of-plant design to be approved by the U.S. Nuclear Regulatory Commission.

SPECIAL REDUCED ALUMNI RATES

THIRTEENTH ANNUAL TOUR PROGRAM — 1977

1977 marks the thirteenth year of operation for this unique program of tours, which visits some of the world's most fascinating areas and which is offered only to alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Univ. of Pennsylvania, Columbia, Dartmouth, and certain other distinguished universities and to members of their families. The tours are designed to take advantage of special reduced fares offered by leading scheduled airlines, fares which are usually available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 over normal air fares. In addition, special rates have been obtained from hotels and sightseeing companies.

The tour program is consciously designed for persons who normally prefer to travel independently and covers areas where such persons will find it advantageous to travel with a group. The itineraries have been carefully constructed to combine as much as possible the freedom of individual travel with the convenience and savings of group travel. There is an avoidance of regimentation and an emphasis on leisure time, while a comprehensive program of sightseeing ensures a visit to all major points of interest. Each tour uses the best hotel available in every city, and hotel reservations are made as much as two years in advance in order to ensure the finest in accommodations. The hotels are listed by name in each tour brochure, together with a detailed day-by-day description of the tour itinerary.

The unusual nature and background of the participants, the nature of the tour planning, and the quality of the arrangements make this a unique tour program which stands apart from the standard commercial tour offered to the general public. Inquiries for further details are invited.

AEGEAN ADVENTURE

23 DAYS $2250

This original itinerary explores in depth the magnificent scenic, cultural and historic attractions of Greece, the Aegean and Asia Minor, including not only the major cities but also the less accessible sites of ancient cities, together with the beautiful islands of the Aegean Sea. Visiting Istanbul, Troy, Pergamum, Sardis, Ephesus and Izmir (Smyrna) in Turkey, Athens, Corinth, Mycenae, Epidauros, Nauplion, Olympia and Delphi on the mainland of Greece, and the islands of Crete, Rhodes, Mykonos, Patmos and Santorini in the Aegean. Total cost is $2050 from New York. Departures in April, May, July, August, September and October 1977. (Additional air fare for departures in July and August.)

SOUTH AMERICA

28 DAYS $2675

From the towering peaks of the Andes to the south Atlantic beaches of Rio de Janeiro, this tour travels more than ten thousand miles to explore the immense and fascinating continent of South America. Visiting Bogota, Quito, Lima, Cuzco, Machu Picchu, La Paz, Lake Titicaca, Buenos Aires, the Argentine Lake District at Bariloche, the Iguassu Falls, Sao Paulo, Brasilia, and Rio de Janeiro. Total

cost is $2675 from Miami, $2691 from New York, with special rates from other cities. Departures in January, February, March, April, May, July, September, October and November, 1977.

THE ORIENT

29 DAYS $2645

A magnificent tour which unfolds the splendor and fascination of the Far East at a comfortable and realistic pace. Visiting Tokyo, the Fuji-Hakone National Park, Kyoto, Nara, Nikko and Kamakura in Japan, as well as the glittering temples and palaces of Bangkok, the metropolis of Singapore, the fabled island of Bali, and the unforgettable beauty of Hong Kong. Optional visits to the ancient temples of Jogjakarta in Java and the art treasures in the Palace Museum of Taipei. Total cost is $2645 from California with special rates from other points. Departures in March, April, May, June, July, September, October and November, 1977 (extra air fare for departures July through October).

MOGHUL ADVENTURE

29 DAYS $2575

An unusual opportunity to view the magnificent attractions of India and the splendors of ancient Persia, together with the once-forbidden Kingdom of Nepal. Visiting Delhi, Kashmir (Bombay during January through March), Banaras, Khajuraho, Agra, Jaipur and Udaipur in India, the fascinating city of Kathmandu in Nepal, and Teheran, Isfahan and the palaces of Darius and Xerxes at Persepolis in Iran. Total cost is $2575 from New York. Departures in January, February, March, August, September, October and November, 1977.

THE SOUTH PACIFIC

29 DAYS $3140

An exceptional tour of Australia and New Zealand, from Maori villages, boiling geysers, ski plane flights and jet boat rides to sheep ranches, penguins, the real Australian "Outback," and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand and Canberra, Melbourne, Alice Springs, Cairns and Sydney in Australia, with optional visits to Fiji and Tahiti. Total cost is $3145 from California. Departures in January, February, March, April, June, July, September, October and November 1977.

EAST AFRICA

23 DAYS $2310

The excitement of Africa's wildlife and the magnificence of the African landscape in an unforgettable luxury safari. Visiting Lake Naivasha, Lake Nakuru, Samburu Reserve, Treetops (Aberdare National Park), Masai-Mara Reserve, the Serengeti Plains, Ngorongoro Crater, Nairobi and Mombasa. Total cost is $2310 from New York. Optional visits are available to the Amboseli and Tsavo National Parks, the Victoria Falls, on the mighty Zambezi River between Zambia and Rhodesia, to Zanzibar, and to the historic attractions of Ethiopia. Departures in January, February, March, May, June, July, August, September, October, November and December 1977.

MEDITERRANEAN ODYSSEY

22 DAYS $1925

A unique and highly unusual tour offering a wealth of treasures in the region of the Mediterranean: Tunisia, with the ruins of Carthage and many other Roman cities as well as lovely beaches, historic Arab towns and desert oases; the beautiful Dalmatian Coast of Yugoslavia, with its fascinating and medieval cities; and the 17th and 18th century splendor of Malta. Visiting Tunis, Carthage, Dougga, Sousse, Monastir, El Djem, Gabes, Djerba, Tozeur, Sbeitla, Kairouan and Thuburbo Majus in Tunisia; Split, Trogir, Sarajevo and Dubrovnik on the Dalmatian Coast of Yugoslavia, and Valletta and Mdina in Malta. Total cost is $1925 from New York. Departures in March, April, May, June, July, September and October, 1977 (additional air fare for departures in June and July).

* * *

Rates include Jet Air, Deluxe Hotels, Most Meals, Sightseeing, Transfers, Tips and Taxes.

Individual brochures on each tour are available, setting forth the detailed itinerary, departure dates, hotels used, and other relevant information. Departure dates for 1978 are also available.

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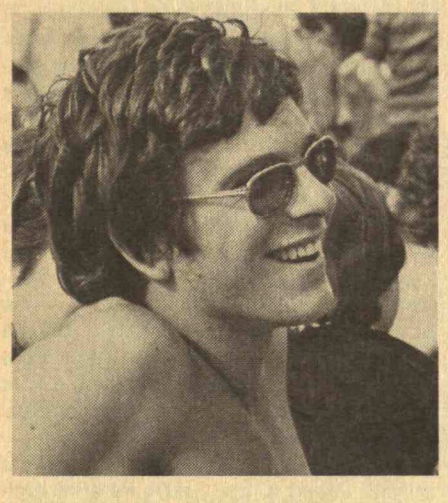
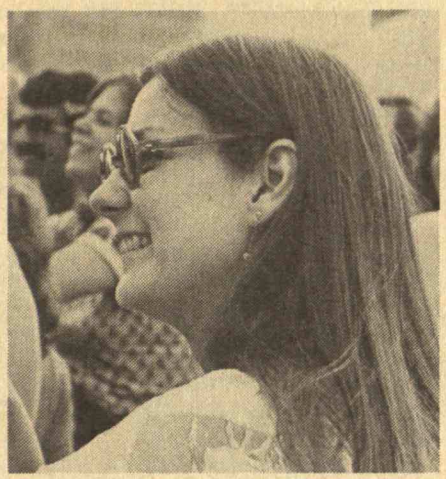




". . . one person the shoe fits," said Paul E. Gray, '54, at the Honors Convocation when he came to the Murphy Award for "contributions (winning) a place in the hearts of students": Julia C. McLellan, Associate Director of Admissions. (Photo: Steven T. Kirsch, '78, from The Tech*)*

T.G.I.F. has the same meaning everywhere, but the manifestations are different. On warm spring days at M.I.T. it's the "Friday Afternoon Club," guaranteed to give every alumnus a bit of nostalgic yearning — relaxation in the sun beside Kresge Auditorium with good (read noisy) music, low-cost beer, and fine fellowship. (Photos: Gordon Haff, '79, from The Tech*)*

Annual Awards Convocation: A Nostalgic, Emotional Ceremony

No one was unmoved at the annual Awards Convocation last spring when 19 individuals and four organizations and programs were honored — a nostalgic, emotional ceremony.

The James N. Murphy Award for an employee "whose spirited contributions to the Institute have won a place in the hearts of students" was presented by Chancellor Paul E. Gray, '54: "Those qualities that endeared Jim Murphy," he said, "a basic concern for the welfare of others; a willingness to go cheerfully not only the second mile but the third and fourth; an intrinsic belief in the dignity of individuals — there is one person that shoe fits: Julia C. McLellan of the Admissions Office."

The Karl Taylor Compton prizes, established in 1954 to recognize "high standards of achievement and good citizenship within the M.I.T. community" were presented by Mrs. Compton to those who, she said, "have in some special way left this place better than they found it." She spoke of M.I.T.: "There is a warmth here that is very rare. You have created that warmth and spirit," she said to the winners: Carolyne Clay, a graduate student, for contributions to minority graduate education; David A. Dobos, '77, for participation in numerous groups including the Interfraternity Conference, the M.I.T. Symphony Orchestra, and athletics; Candace J. Gibson, a graduate student, for initiative in developing a graduate student orientation program and activities on behalf of admissions of women graduate students; Robert G. Resnick, '77, for contributions to the Residence/ Orientation program and participation in numerous other activities; Marian S. Tomusiak, '77, for sustained service to Alpha Phi Omega and the Student Center Committee. The M.I.T. Shakespeare Ensemble received the organizational award, accepted by Jonathan D. Ivester, '77.

Frank C. Richardson, '77

Greatest Distance Runner

David A. Dobos, '77

M.I.T.'s all-time greatest distance runner is Frank Richardson, '77. The four-time All-American captured the 10,000-meter run at the N.C.A.A. Division II National Track and Field Championships at Calvin College in Grand Rapids, Mich., on May 27 to climax a brilliant collegiate running career.

In winning this last collegiate victory, Frank shook off perennial rivals Peter Kummant of Case Western Reserve and Paul Oparowski of Bates 2.5 miles into the 6.21-mile race and then pulled away to a winning margin of over 250 yards. His time of 29:50.8 missed the meet record by a scant three seconds.

Frank Richardson has compiled a spectacular collegiate record at M.I.T.: All-American honors twice each in cross country and outdoor track, fourth in the 1975 N.C.A.A. Division III three-mile run, fifth and fourth, respectively, in the 1975 and 1976 National Division III Cross Country Championships, winner of 13 of 15 dual/triangular cross country meets, the I.C.A.A.A.A. individual cross country championship for 1976, new M.I.T. varsity track records in the indoor two-mile (8:54.4) and three-mile (13:48.96) and the outdoor three-mile (13:43.0) and six-mile (28:49.6), winner of the Greater Boston three-mile and the Eastern College Division six-mile (1977), and runner-up in the I.C.A.A.A.A. university division 10,000-meter race (1977). Running in the N.C.A.A. Division I Championships, he placed 12th (29:38.0) against Olympic-caliber runners. Discounting the foreign athletes recruited for the college track powerhouses, Richardson finished seventh among the native American university runners.

Because of these many accomplishments, Richardson was named this spring for the Institute's top athletic honor, the Class of '48 Award for the senior athlete of the year. And, because his academic performance has been so high, he also received the Kispert Award as M.I.T.'s best scholar-athlete. Never before has one person won both of these coveted awards.

Professor Peter M. Close, Head Cross Country Coach and Assistant Track Coach — he leaves M.I.T. this summer for Tufts, where starting next fall he will head the entire track and cross country program — terms his star pupil's collective collegiate performance as "one helluva career." That's especially true because Richardson had "plenty of disappointments along the way." He was out of athletics for six months of his freshman year because of a crushed vertebra from a car accident the summer before entering the Institute. Indeed, Richardson is still bothered somewhat by this back injury, and 1976-77 was the first year in which he completed all three seasons — cross country and indoor and outdoor track — health intact.

Richardson and Professor Close have worked together to determine the athlete's optimum training. Because of his back, Richardson cannot run speed workouts very often; so he does a great deal of distance work. Preparing for the spring season, Richardson covered over 100 miles per week. For the championship meets, he cut his workout distance in half to avoid tiring and to retain the sharp, competitive edge he had attained from previous work.

Richardson's racing strategy reflects his running strengths. He refrains from a quick, opening pace; instead, he gradually catches the early leaders, runs with them for awhile, and then pulls away. For example, in winning the Nationals, he took the lead at the 3/4-mile mark, left his final two opponents at 2-1/2 miles, built an insurmountable lead during the next three miles, and coasted to the finish. His stamina is his greatest asset. He wins races with his consistent, punishing pace.

This is not an end for Richardson. He believes that he can still improve a lot, and during his next four years at the Iowa State University School of Veterinary Medicine he will continue with his running as faithfully and enthusiastically as he did at M.I.T.

Watch for him in future national competitions.

David A. Dobos, '77, wrote regularly for The Tech *and occasionally for* Technology Review*; and was a member of the varsity cross-country and track teams. He'll enter law school in September. (Richardson photo by Herbert Ule, '79, from* The Tech*)*

Recapping a Lackluster Spring Sports Season

Glenn Brownstein, '77, wrote for *The Tech* — mostly about sports — throughout his four-year M.I.T. career. In the last issue of the spring, just before graduation, Mr. Brownstein recalled some of his favorite memories . . .

. . . the women's volleyball Eastern championship in 1976 . . . the men's varsity basketball win (70-69) over Suffolk University in February . . . winning the "Little Iron Man" fencing trophy in 1974 . . . the rugby team's New England title in 1974 . . . and that famous Northeastern home run in 1974 over the "tennis bubble," a bounce on the Burton lawn, and finally stopped on Burton House about eight feet off the ground . . .

Only one of Mr. Brownstein's memories is from the 1977 spring season — his article was written before Frank Richardson's triumph at the N.C.A.A. Division II championships (*see left*). The 1977 season was sort of like that — not very memorable.

The track team, led by Mr. Richardson, came out of its regular season with three wins and only one defeat, then went on to take fifth in the Greater Boston championships. Lacrosse was almost as good — the best season since 1969, with a final 8-4 record; the eight victories in 1977 were more than M.I.T. had accumulated in the last four years combined. The golfers' spring season record was 8-7.

But there the good news ends. As the season began, Crew Coach Peter A. Holland told Bob Monahan of the *Boston Globe*, "On paper we have some talent. . . . If we can get the right people working as a unit as quickly as possible, we could be pretty good." But it hardly ever happened that way: it was all downhill after a strong opening against Columbia. The varsity beat only Brown in the qualifying heat of the Eastern Sprints at Princeton in May.

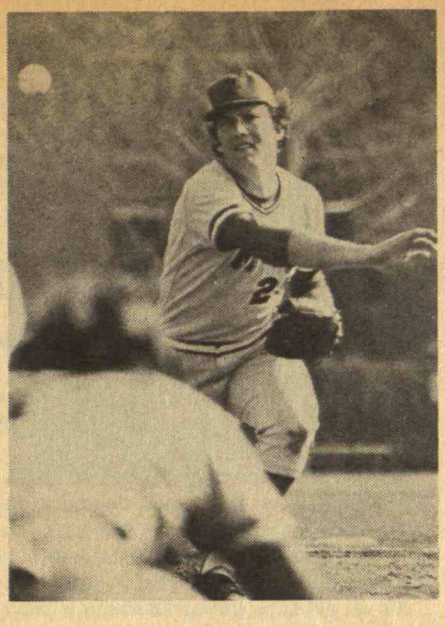
A similar fate befell the baseball team. With four starters graduating last June, the team could expect "tough going," opined Thomas A. Curtis, '80, of *The Tech*. He was right: in the third week of the season the Beavers dropped their eighth, ninth, and tenth games in a row — the longest losing streak since 1964.

Lacrosse: A "High-Powered Attack" by the Alumni, but They Settle for a Tie

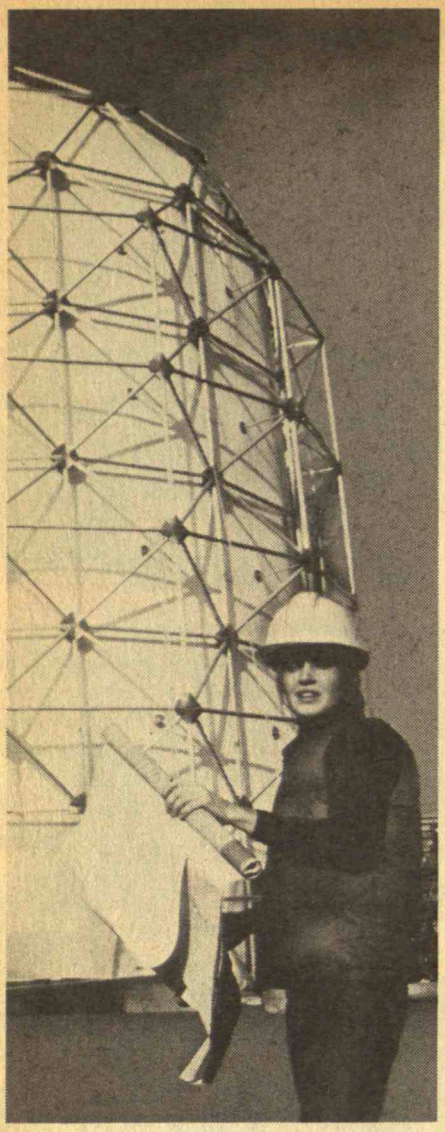
Lacrosse games aren't supposed to end in ties, but after two four-minute overtimes failed to resolve the varsity-alumni contest on May 14, everyone decided enough was enough. Here's how Glenn Brownstein, '77, Editor-in-Chief of The Tech*'s Volume 96, described the sweaty stand-off:*

Proving the modified adage that old lacrosse players never die, an alumni team from the last ten seasons weathered a fourth-quarter collapse to pull out a 15-15 double-overtime tie against M.I.T.'s varsity squad.

Both old and young contributed to the alumni's strong showing: three-time team-



*Highlights of spring sports: star pitcher Kenneth L. Smith, '77 . . . Jim F. Turlo, '80, in the long jump (*The Tech *called him "one of the outdoor track team's freshman sensations") . . . varsity rugby scrimmage . . . the women's crew vs. the University of New Hampshire . . . and evidence that the posters were right: "women can play rugby, too!" (the picture was taken during the M.I.T. women's rugby club first game). (Photos: Gordon R. Haff, '79, from* The Tech *and the* Boston Globe.



Erika Franke, '77, is receiving her bachelor's degree in architectural design this June. But she's already had three years of field experience with Dome East Corp., for whom she supervised erection of this derrick enclosure — the world's largest — aboard Deepsea Ventures, Inc.'s, R/V Deepsea Miner II. The enclosure, built of aluminum struts and hubs, aircraft hardware, and a vinyl-on-polyester membrane in light tension, was erected from the top down and installed on the ship in four days — a new record for such a large space-frame structure. There's special satisfaction in such field work, says Ms. Franke: it's "engineering translated into action."

leading scorer George Braun, '75, celebrated his return to M.I.T. with six goals and two assists, while JV goalie Wes Harper, '79, called on to fill the net for the short-staffed alumni, played the best game of his career in turning back 25 varsity shots.

The varsity's star was of some vintage as well: attackman Steve Hyland, '77, a sometime student for several years, scored four goals, including one that climaxed a desperate varsity rally and sent the game into overtime.

The squads battled through a 3-3 first quarter before the alumni, paced by the scooping and shooting of ancient Steve Schroeder, '67, opened up a three-goal lead that the varsity cut to 7-5 by halftime. Schroeder scored twice, added an assist, and scooped four grounders in the second period.

At halftime, varsity goalie Jeff Singer, '77, had 11 saves against the alumni's high-powered attack and Harper had but six against the varsity. Yet the goalies' usual roles were reversed in the second half, Harper making 15 saves in the last 30 minutes of regulation time and Singer just four.

Singer's chief nemeses in the second half were Braun (two goals, one assist) and 1975 high-goal-scorer Bob Laurenson, '75 (two goals).

Both teams scored twice in the third quarter, but Al O'Connor, '79, and 1977 leading goal scorer Phil MacNeil, '79, pumped in two quick goals to tie the game, 9-9 after just two minutes of the fourth quarter.

Stu McKinnon, '78, a "ringer" used by the alumni to help its depleted ranks (McKinnon took a term off this spring, but will return to the varsity next year as a junior), flipped in a 15-footer at 2:43 to make it 10-9, and Laurenson and Braun added scores to give the "old men" a 12-9 lead with four minutes left in regulation.

Hyland scored at 11:58 to pull the varsity within two, but it took two goals in the final minute to gain a 12-12 tie. Gordie Zuerndorfer pumped one past Harper on a fast break feed from co-captain Roger Renshaw, '77, with just 56 seconds left, and then Hyland picked the top left corner and beat Harper with just nine seconds left to send the game into two four-minute overtime periods.

The alumni struck first in the extra sessions, building a 14-12 lead on two quick Braun goals (39 seconds apart), but O'Connor came back to make it 14-13 after one overtime. In the second mandatory extra period, the varsity tallied twice in just nine seconds (0:34 and 0:43 of the period), but Braun flipped in a loose ball with two minutes remaining to tie the score at 15, the final score as the teams decided not to play a sudden-death tiebreak overtime.

Cheers for Erika Franke: She Likes Action in Her Engineering

Dome East Corp. of Hicksville, N.Y., has just completed designing, building and installing the world's largest derrick enclosure — 52 feet in diameter, 70 feet high. It's aboard the R/V Deepsea Miner II, sailing out of California for Deepsea Ventures, Inc., and the installation job was done by a crew of 12 union shipyard workers at Northwest Marine Iron Works, Portland, Ore.

Nothing so unusual about that. But look again.

The assembly and installation were done in record time under the supervision of an M.I.T. co-ed, Erika Franke, '77.

Ms. Franke is no stranger to such work. She received her bachelor's degree in architectural design this June, but as a student she's worked on ten other Dome East projects in the last three years.

It's an exacting job, assembling a precision building fabricated 3,000 miles away. But M. Franke likes it; she gets personal satisfaction, she says, form working in the field, "where engineering is translated into action."

She also takes pride in her role in breaking down traditional sex barriers. "Gender-identified work is becoming a thing of the past — especially in innovative companies," says Ms. Franke. "The essential issue now is whether or not one can get the job done."

But Ms. Franke has to prove it all over again on every job. "The first day on the site is always the hardest," she says. "You get started at 8 o'clock in the morning with 12 workers who may have no experience with a woman supervisor. You have to show them quickly that you know what you're doing." Usually that's done within the first day, and then everyone settles into the job with confidence and skill.

It's Easy and Cheap to Cook in Your Room, and It's Also Illegal; but Terry Fisher Has an Answer

Cooking in M.I.T. dormitories?

Strictly prohibited, a decade and more ago. But in a new age of relaxed, often co-educational living, when costs are up and students' resources pinched tighter and tighter. . .

A threatening complication this spring from George Kessel, Cambridge's Housing Code Enforcement Inspector. After a routine inspection, Mr. Kessel announced that M.I.T. dormitories are in violation of the Cambridge Housing Code. " . . . all cooking and eating in rooming units (bedrooms) must be *discontinued immediately,*" he wrote in a letter which was promptly posted in all the Institute Houses.

Kenneth C. Browning, '66, Associate Dean for Student Affairs, told *The Tech* that the city was within its rights, that "[cooking] is against the code." But "we'll be discussing it," he said, which is where the matter seemed to stand as the term ended.

What's bad news for dormitory residents

For the first time at M.I.T., two married couples were among those receiving commissions: Marilyn K. McQuade (right) and Peter D. McQuade, were commissioned second lieutenants in the Air Force; Linda D. Pirek and Ronald C. Pirek were commissioned ensigns in the Navy.

may be very good news for Terry Fisher, who's just finished her first year of graduate work in nutrition and food science. She's the author of *The International Students' Guide to Cooking Without Getting Caught* (Ashley Books, $4.95) — a manual on how to make a decent meal with an iron, a thermos, a hot pot (in which to boil water), and a few pots and plates.

The idea came to Ms. Fisher while she was an undergraduate at the University of Virginia, where there were strict no-cooking rules: no toasters, no hot plates, no portable broiler ovens. But she wanted to save money, so she devised such procedures as cooking foil-wrapped sandwiches and steaks with an iron, cooking bread by steaming it on top of a hot pot, and using a thermos to stew food.

She wrote all this up as an independent study project for undergraduate academic credit, and then someone suggested it might make a book. "I never expected to get it published — it was just kind of freaky," Ms. Fisher told *The Tech* this spring.

A threatened ban on cooking in M.I.T. dormitories – it's against the Cambridge Housing Code – will be good news for Terry Fisher, a first-year graduate student in nutrition who's looking for a market for her new book: The International Students' Guide to Cooking Without Getting Caught. *(Photo: Mark James, '78, from* The Tech*)*

Two Married Couples are Among Those Who Received Commissions

"If you aren't having fun you aren't doing it right," Rear Admiral Ralph R. Hedges, Commander of the Naval Patrol Wings, United States Atlantic Fleet, told 14 Navy midshipmen, six Army cadets and five Air Force cadets commissioned June 3 at M.I.T. "There is no paved way to the top; no right way," he continued. "But it is important for you to do each job to the best of your ability — it is performance that counts. And all jobs are important, if for no other reason than it's your job."

When beginning a job, he said, find out who you work for; find out what he wants; and give it to him. It may be difficult, he added, to find out who you work for. It may not be easy to find out just what he wants — sometimes that is not perfectly clear to him. The third is easy.

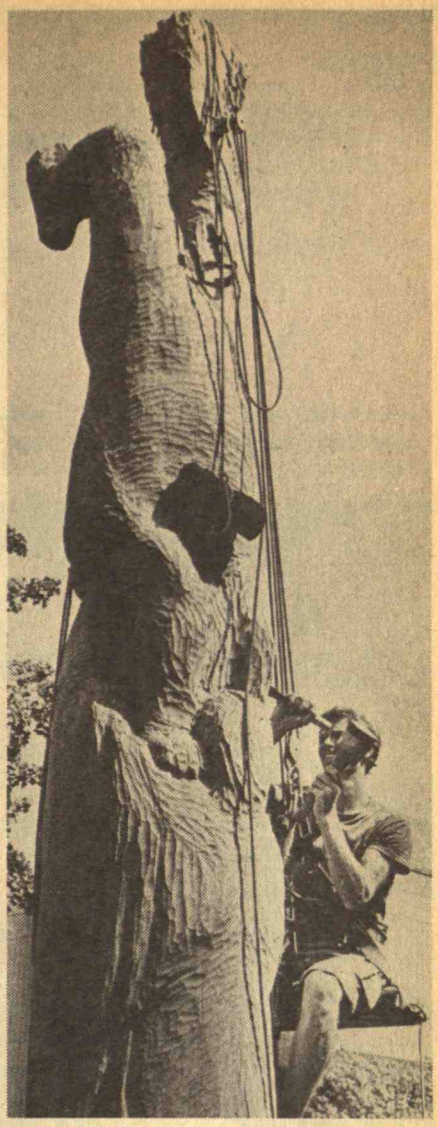
The ceremonies marked the first time women had received commissions in the Army and two in the Navy through M.I.T. R.O.T.C. programs. (The Air Force commissioned its first woman student at M.I.T. in 1975).

Pershing Rifles Win Hands Down

A very good day for the Pershing Rifles, the R.O.T.C. drill team, at the New England Regimental Competition this spring.

With half of the 12 awards presented, M.I.T. left the field victorious — easily — over all other entries: Best Company Award, Best Tactical Group, Best Drill Platoon, Best Rifle Platoon, Best Commanding Officer, and Best Executive Officer. And a special citation to Barbara K. Ostrum, '78, as Best Administrative Officer of the year.

M.I.T.'s Pershing Rifles were reactivated in 1972 after a hiatus during the years of the Vietnam War; now the unit is at full strength — 40 members, some 20 per cent of them women.



When he graduated last month, Frederick W. Faller, '77, left behind a unique monument to his skills with hammer and chisel: a modern "totem pole" carved in a dead, standing elm trunk outside 85 Putnam Ave., Cambridge. The motif shows one man doing a handstand on another's shoulders, and Mr. Fuller said he and a friend worked on it six to eight hours a day for most of April and all of May. Calvin Campbell of the M.I.T. News Office, who took the picture, forgot to ask Mr. Fuller how one has so much spare time during the last two months of the senior year at M.I.T.

Even before he was officially sworn in, Frank Press, on leave from his post as Shrock Professor of Earth and Planetary Sciences at M.I.T., "has been very helpful in helping me to make the right decisions," says President Jimmy Carter of his new Science Adviser. At the ceremonies conducted by Judge David A. Bazelon in the rose garden on May 26, Dr. Press stood between President Carter and Mrs. Press; the President said the appointment marked "a great step forward in recementing the relationship between scientific knowledge . . . and (its) political application," and he promised that Dr. Press would be "an integral part of my administration." (Photo: White House)

Toward World Security in an Era of Change

What practical initiatives can the nations of the world take, individually and collectively, to gain better control of our more dynamic world?

Ten distinguished world leaders were asked to respond to that question in lectures on World Change and World Security at M.I.T. last winter and this spring. Their answers turned out to represent authoritative reviews of many of the most familiar and most frustrating issues before mankind already posed in a position paper from the faculty committee charged with planning the series: north-south relations, i.e., the conflicting interests and priorities of the developed and underdeveloped nations; east-west relations, the long-sought accommodation between the socialist governments of Asia and Eastern Europe and the Western democracies; resource constraints, the growing competition for resources as reserves are depleted and population and industrialization increase; institutional constraints, the growing difficulty of government in managing or even influencing the course of increasingly complex societies; the escalation of violence; and the proliferation of sophisticated military weapons and systems of destruction, principally those based on nuclear explosives.

There were addresses by Roy Jenkins, President of the Commission of the European Communities; Canon Burgess Carr, General Secretary of the All-Africa Conference of Churches; Willy Brandt, Chairman of the Social Democratic Party of Germany; McGeorge Bundy, President of the Ford Foundation; David A. Hamburg, President of the Institute of Medicine; Sigvard Eklund, Director General of the International Atomic Energy Agency; Roberto de Oliveira Campos, Brazilian Ambassador to Great Britain; Georgi A. Arbatov, Director of the Institute of U.S. and Canadian Studies of the Academy of Sciences of the U.S.S.R.; Robert S. McNamara, President of the World Bank; and Frank Church, U.S. Senator.

Excerpts from some are shown in the adjacent column. The entire series will be published, as edited by President Jerome B. Wiesner and Norman C. Dahl, Sc.D. '52, who was Chairman of the Lecture Series Committee, by the M.I.T. Press early in 1978. Meanwhile, recordings of the lectures are being presented throughout this summer by radio stations in the Public Broadcasting System network, and readers may wish to inquire of local stations for schedules.

"We are [not] in a position to speak about a choice between different alternatives which may supply us with energy. . . . Man's curiosity and his efforts to . . . apply his findings for the betterment of life . . . cannot be stopped by artificial means, and that is the fundamental reason why I do not think it is possible to put [a] lid [on] future application of nuclear energy for power generation."

Sigvard Eklund, Director General of the International Atomic Energy Agency

"However well intentioned, I am convinced that the administration's nuclear energy policy is a formula for nuclear isolationism. It will reduce — not enhance — U.S. influence in shaping worldwide nuclear policy. Thus, instead of advancing the control of nuclear weapons proliferation, our self-imposed restraint runs the grave risk of leaving an international vacuum, which is an invitation to nuclear anarchy."

Senator Frank Church

"It is not sufficient to discuss whether it would be politically desirable to reduce to a reasonable level the thinking in terms of national sovereignty and to develop new forms of frontier-crossing cooperation; the pressure of circumstances, correctly understood, leaves us no other choice."

Willy Brandt, Chairman of the Socialist Democratic Party of Germany

". . . The pivotal element of policy for the future — whether it is only for next year or for the next 20 years — will be the preservation, advancement, and consolidation of détente. . . . Without détente, . . . we shall not be able even to [begin] with the solution of practically all of the problems listed for discussion in the present series of lectures."

Georgi A. Arbatov, Director of the Institute of U.S. and Canadian Studies of the Academy of Sciences of the U.S.S.R.

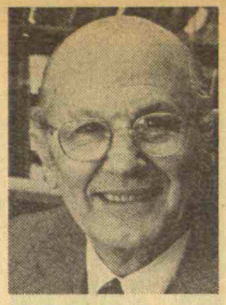
"Barring a holocaust brought on by man or nature, the world's population tonight — as we sit here — is the smallest it will ever be again. . . . For every decade of delay in achieving a net reproduction rate of 1.0 — replacement-level fertility — the ultimate steady-state world population will be approximately 15 per cent greater. . . . Short of nuclear war, the . . . issue of population growth is the gravest issue the world faces over the decades immediately ahead."

Robert S. McNamara, President of the World Bank


W. A. Baker


M. B. Bever


E. Catalano


M. Cohen


B. S. Gould


E. N. Hartley

Twelve Teachers Are Among 130 Who Retire on June 30

The "process of shifting gears" has begun for M.I.T. and for 130 members of its faculty and staff who retired on June 30.

It's a big change for both sides. The new way of life on which those retiring now embark is immensely appealing to the rest of us. But — left behind at the Institute — our task is to fill gaps and holes created by the departure of people whose collective experience represents 2,572 years of service.

Credit these paraphrased observations to Paul E. Gray, '54, Chancellor of the Institute, presiding at the annual dinner for this year's retirees.

This year's roster contains many familiar names — nine members of the faculty and three lecturers who have had major influence on the intellectual life of the Institute and whose careers and contributions are inadequately summarized below. Others, too, who kept the wheels of learning turning smoothly: Eleanor L. Bartlett, Archives Librarian; Gertrude E. Bruns, Administrative Officer of the Sloan School of Management; G. Peter Grant, '35, Special Assistant to the Vice President of the Alumni Association; Mary Manning, Administrative Secretary in the Educational Council office; Margaret E. Norton, Administrative Secretary in the Electronic Systems Laboratory; Robert J. Raddocia, Manager of Walker Memorial; Arthur R. Schott and Evelyn B. Wheeler of the Housing Office; and Patricia M. Sprissler, Administrative Secretary in the Department of Physics Undergraduate Office.

Four of those retiring have served for 40 years or more at M.I.T.: Professors Morris Cohen, '33, Bernard S. Gould, '32, and Clark C. Stephenson, and Leotha L. Woertz of the Comptroller's Accounting Office.

The moment is especially poignant for teachers and professionals, whose scholarship is embedded in alumni and recorded in journals. Special notice, then, to the 12 retiring members of the teaching staff:

☐ **William A. Baker,** '34, Lecturer in the Department of Ocean Engineering, climaxed a career in shipbuilding with Bethlehem Steel Co. when he returned to the Institute in 1963 as Curator of the Francis Russell Hart Nautical Museum. He was a prolific contributor in the field of ship structures and design for Bethlehem for 30 years while following his avocation of marine history, including studies of ship models, medieval and 17th century ship design, and yacht design; and he has turned his knowledge of history and structures to the design of modern replicas, including most notably *Mayflower II,* which was sailed from England in 1957 and is now owned and exhibited by Plimoth Plantation, Inc., in Plymouth, Mass. Mr. Baker is a member of the Editorial Board of the *American Neptune,* and he's written and consulted on a number of historical works with the Swedish publishing house of Tre Tryckare.

☐ **Michael B. Bever,** Sc.D. '44, Professor of Materials Science and Engineering, came to the U.S. from Heidelberg, where he had completed undergraduate work in metallurgy, in 1937 — first to Harvard for an M.B.A. degree and then to M.I.T. for his doctorate with a thesis in physical metallurgy. Thereafter for over 20 years he focused his research on the solidification and hardening of metals, deformation processes, and recrystallization — studies which led to the Mathewson Gold Medal of A.I.M.E. in 1965. Since then Dr. Bever has turned his painstaking research to mineral economics, especially recycling and secondary materials markets, leading in 1972 to the Recycling Award of the National Association of Secondary Material Industries.

☐ Ten years ago **Eduardo Catalano,** Professor of Architecture, was listed among the "ten leading architects of the world," and his recent work assures that he is currently ranked in the same way. At M.I.T. since 1956 (he was previously Head of the Department of Architecture at North Carolina State University, Raleigh), Professor Catalano was trained in his native Argentina and at Pennsylvania and Harvard. Among his buildings are the Stratton Student Center, the Hermann Building, and Eastgate at M.I.T., a new government center in Greensboro, N.C., the Juilliard School of Music in Lincoln Center, New York City (in association with Pietro Belluschi), and the civic center of Portland, Maine.

☐ Now a member of the Charles S. Draper Laboratory, **Godfrey T. Coate,** '47, joined the M.I.T. faculty in 1945 to teach electronic circuit theory; since 1954 he's served as Lecturer while concentrating on radar research in the Electronic Systems Laboratory and — more recently — the Draper Laboratory. His undergraduate (B.S. 1937) and graduate (M.S. 1939) degrees are from Tulane University.

☐ **Morris Cohen,** '33, Professor of Materials Science and Engineering, has been a major catalyst of the changes which have since World War II transformed the discipline of metallurgy into materials science and engineering and broadened its scope to include materials policy as well as technology. He joined the faculty a year after receiving his doctorate (Sc.D. 1936) from the Institute, and his entire professional life has thus been spent here — working first on technical metallurgical research in thermodynamics and mechanical properties and more recently on materials policy and its unification with materials science and engineering; he was designated Institute Professor in 1975. Professor Cohen holds countless major awards and prizes, including two presentations of the Howe Medal of the American Society for Metals (1945 and 1949), the Mathewson Medal of the A.I.M.E. (1953) and the Proctor Prize of the Scientific Research Society (1976), and he has given major lectures throughout the world, including the Killian Lectures at M.I.T. in 1974.

☐ **Bernard S. Gould,** '32, Professor of Biochemistry, outranks them all: he has been a member of the staff and faculty of M.I.T. for 43 years — since 1934, when he became an instructor in the Department of Biology having just returned from the University of London with a Ph.D. degree. Since then he has studied and taught protein biosynthesis, enzyme chemistry, and wound healing; and his advice, both official and unofficial, has won the praise of countless M.I.T. undergraduates seeking entrance to medical school.

☐ **E. Neal Hartley,** Professor of History, came to M.I.T. in 1946 after World War II service in the U.S. Navy; he had completed undergraduate and graduate work at Harvard before the war. Professor Hartley's field is American history — and especially the early history of technology in the U.S.; he was active in the restoration of the country's first iron works in Saugus, Mass., has


P. M. Hurley


R. S. Morse


J. F. Reintjes


J. C. Sheehan


C. C. Stephenson

studied the development of the U.S. steel industry, and — since 1966 — has been Archivist of M.I.T.

☐ When the theory of continental drift and plate tectonics came into its own a decade ago, **Patrick M. Hurley,** Ph.D. '40, Professor of Geology, was one of the proponents and major contributors. He had already made important geological analyses by applying nuclear science to geological time measurements, and his work in mineral exploration provided a basis for showing how geological provinces extended across what now appear to be distinctly separate continental land forms. Professor Hurley was born in Hong Kong and raised in Canada, where he attended the University of British Columbia (B.A. 1934). He has been at M.I.T. since 1938, when he joined the Department of Geology as a Teaching Fellow.

☐ **Richard S. Morse,** '33, Senior Lecturer in the Sloan School of Management, began his professional career at Eastman Kodak Co. after completing his M.I.T. degree in electrical engineering. But five years later his interest in technological innovation and entrepreneurship won out, and he became President of National Research Corp. and Vacuum Metals Corp., Cambridge-based firms which pioneered new applications of vacuum cooling and drying. For two years beginning in 1959 he was Assistant Secretary of the Army (Research and Development), and since 1963 he's been teaching at M.I.T. — including a popular course on how management, technology, and politics are brought to bear on government decision-making. As Director of the M.I.T. Development Foundation from 1972 to 1976, Mr. Morse sought commercial exploitation of M.I.T. technology.

☐ **J. Francis Reintjes,** Professor of Electrical Engineering, was Director of M.I.T.'s Electronic Systems Laboratory — formerly the Servomechanisms Laboratory — from 1953 to 1975; its goal was to apply computer-based automatic control and analysis systems to a wide variety of technical and management problems, and its work ranged from numerically controlled machine tools to systems for scheduling and routing newspaper delivery trucks. In addition, for much of this period Professor Reintjes was Director of Course VI-A, the cooperative program in electrical engineering, and earlier he had made significant contributions through research and teaching on radar principles.

☐ A long career in organic chemical synthesis was climaxed for **John C. Sheehan,** Professor of Organic Chemistry, with issuance of patents covering semi-synthetic penicillin; he has also done research on the synthesis of beta-lactams, amino acids, peptides, alkaloids, and steroids. At M.I.T. since 1946, Professor Sheehan studied at Battle Creek (Mich.) College (B.A. 1932) and the University of Michigan (Ph.D. 1941); he was research chemist at Merck and Co. from 1941 to 1946. He holds major awards from the American Chemical Society, of which he is a Director, and he's lectured widely in the U.S. and overseas.

☐ **Clark C. Stephenson,** Professor of Chemistry, is well known for his studies of the thermodynamic functions of many elements and inorganic compounds and for his active role in organizing and teaching M.I.T.'s first-year chemistry course, for which he had responsibility during the 1950s and to which he has continued to contribute experiments in physical and inorganic chemistry. His reputation as a superb teacher is founded, as well, on his handling of upperclass and graduate subjects in physical chemistry. Professor Stephenson studied at the University of Kansas and the University of California in Berkeley (Ph.D. 1936) and came to M.I.T. in 1937.

Alfred Keil Leaves the Dean's Office

Alfred A. H. Keil, who has been Dean of the School of Engineering since 1971, will leave that assignment at the end of the summer to become Ford Professor of Engineering, thus turning from administrative work to teaching and research.

The School of Engineering is M.I.T.'s largest, and President Jerome B. Wiesner says Dean Keil has "provided leadership to the School during a period in which the complexions of engineering practice, and thus of engineering education, have changed significantly, and enrollments in the School have increased dramatically. His efforts to articulate a new and broader vision of engineering education and to use the resources of the School with increased effectiveness have made a lasting contribution."

James D. Bruce, Sc.D. '64, who's been Associate Dean, will become Acting Dean.

Individuals Noteworthy

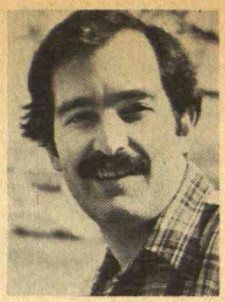
Honors and Awards to the M.I.T. Community

Lawrence R. Susskind, Ph.D. '73, Associate Professor and Assistant Department Head of the Urban Studies and Planning Department, reappointed as a member of the Metropolitan Area Planning Council, Boston . . . to **Bernard T. Feld,** Professor of Physics, an honorary Doctor of Science degree from Coe College, Cedar Rapids, Iowa . . . **Jack H. Frailey,** Director of the Student Financial Aid Office, to President and Chief Executive Officer of the National Association of Amateur Oarsmen . . . **Albert G. H. Dietz,** '32, Professor of Building Engineering Emeritus and Senior Lecturer in the Department of Architecture, named Man of the Quarter Century by the Building Research Advisory Board of the National Academy of Sciences-National Academy of Engineering-National Research Council . . . **Michael S. Baram,** Associate Professor of Civil Engineering, appointed to the Advisory Committee on Construction Safety and Health of the Occupational Safety and Health Administration.

Appointments: Rising in the World of Business

Albert J. Kelley, '48, Dean of the School of Management of Boston College to President, Arthur D. Little Program Systems Management Company . . . **Harold S. Glenzel,** '51, Manager, buildings and real estate, New England Telephone, to Vice President, buildings and real estate, New England Telephone . . . **R. Clark Harris,** S.M. '72, Manager of Operations Analysis for United Technologies, to Factory Manager, Sikorsky Aircraft Division of United Technologies.


Y. Ayukawa


V. S. Castellano


D. R. Clare


H. A. Hill


C. G. Koch


J. McAfee

Nine New Members and Seven Changes on the Corporation

Nine new names now grace the roster of the M.I.T. Corporation, and seven of its members now have new appointments to the Institute's governing body in which is vested the trusteeship of M.I.T.

The new members are:

☐ **Yaichi Ayukawa,** '52, Chairman of CPC Japan, Ltd., is a leader in the Japanese food industry. Dr. Ayukawa holds three degrees — in food science and industrial management — from M.I.T., and he's played a major role in enlisting important support for the Institute from leading Japanese industrial organizations.

☐ **David R. Clare,** '45, President and Chairman of the Executive Committee of Johnson and Johnson, studied mechanical engineering at M.I.T. and joined Johnson and Johnson almost immediately upon graduation; he's been a principal executive in the company since taking charge of its domestic operations in 1970.

☐ **Henry A. Hill,** Ph.D. '42, is President and Founder of Riverside Research Laboratories, Inc., of Haverhill, Mass. Earlier he was with Atlantic Research Associates, Vice President for Research at National Atlantic Research Co., and Vice President of Dewey and Almy Chemical Co. He's currently President of the American Chemical Society, of which he's played an active role for many years.

☐ **Charles G. Koch,** '57, Chairman of Koch Industries, Wichita, Kans., has M.I.T. degrees in general engineering, mechanical engineering, and chemical engineering; he's been a member of the Corporation's Visiting Committee to the Department of Chemical Engineering and of the National Sponsoring Committee enlisting support for construction of the Ralph Landau Building for chemical engineering.

☐ **Jerry McAfee,** Sc.D. '40, Chairman and Chief Executive Officer of Gulf Oil Corp., has been at Gulf since 1944, and he held several research and management positions at the vice presidential level before assuming his present post in 1976. He, too, is a former member of the Visiting Committee in chemical engineering and of the Landau Building sponsoring committee, and he's a former President of the American Institute of Chemical Engineers.

☐ **Denman K. McNear,** '48, joined Southern Pacific upon graduation from M.I.T.; he's now President of the Southern Pacific Transportation Co. and of the St. Louis Southwestern Railway Co. Mr. McNear's M.I.T. degree is in civil engineering, and he's since studied for a master's degree in management from Stanford.

☐ **F. Richard Meyer III,** '42, graduated from the Institute in management and worked in the executive offices of Stewart Warner Corp. and later Acme Steel Co. before founding his own consulting office specializing in corporate mergers and acquisitions. Mr. Meyer is a former Director of the Alumni Association and former President of the M.I.T. Club of Chicago.

☐ **David S. Saxon,** '41, joined the physics faculty of the University of California at Los Angeles in 1947, where he gradually assumed increasingly important administrative duties: Chairman of the Physics Department (1963-66), Dean of Physical Sciences (1966-69), Executive Vice Chancellor (1968-75), and Provost (1974-75). Then he was chosen President of the University of California statewide system in 1975.

☐ **Vincent S. Castellano,** S.M. '77, graduated in 1974 from Syracuse University in electrical engineering and biosystems, and this year he received two master's degrees from M.I.T. — in electrical engineering and management. For the past two years he's been a teaching assistant in electrical engineering and a graduate resident tutor in Baker House.

Messrs. Ayukawa, McNear, and Meyer were nominated for Corporation membership by the Alumni Association, and Mr. Castellano was nominated by members of M.I.T.'s three most recent graduating classes. All new term members serve for five years.

Four Life Members

With their five-year terms expiring, four members of the Corporation became Life Members on July 1; they are:

☐ **Breene M. Kerr,** '51, Partner in the Resource Analysis and Management Group and Chairman and Chief Executive Officer of H-K Corp., both in Oklahoma City.

☐ **Frank R. Milliken,** '34, President, Chief Executive Officer, and Director of Kennecott Copper Co.

☐ **Clint W. Murchison, Jr.,** S.M. '47, partner in Murchison Brothers, Dallas, and owner and Chairman of the Board of the Dallas Cowboys professional football team.

☐ **Gregory Smith,** '30, former President and General Manager of Eastman Gelatin Corp., Peabody, Mass.

Two term members have been re-elected for five-year terms:

☐ Dr. **W. Gerald Austen,** '51, Chief of Surgical Services at Massachusetts General Hospital.

☐ **W. Van Alan Clark, Jr.,** S.M. '42, President and Chairman of Sippican Corp., Marion, Mass.

Norman B. Leventhal, '38, now has two portfolios as a member of the Corporation; he was elected to a five-year Term Member in 1975, and this year he becomes an ex-officio member by virtue of his election as President of the Alumni Association.

Kudos at M.I.T.

To **Elizabeth R. Leeds,** doctoral candidate in political science, a Fulbright-Hays grant for research on migration policy in Portugal . . . to **Rafael L. Bras,** '72, Assistant Professor of Civil Engineering, a National Science Foundation Research Initiation Grant ($19,900 for hydrologic models research) . . . to **Roger D. Flood,** '72, **Thomas O. Mason,** and **Edwin K. Schneider** — all three are doctoral candidates — N.A.T.O. Postdoctoral Fellowships.

Nevin S. Scrimshaw, Head of the Department of Nutrition and Food Science, is the U.S. Department of Agriculture's ninth W. O. Atwater Memorial Lecturer; he'll address the Western Hemisphere Nutrition Congress in Quebec in August. . . . **Eugene E. Covert,** Professor of Aeronautics and Astronautics, to the Board of Directors of ARO, Inc., operators of the Arnold Engineering Development Center.

To **Bruno Coppi,** Professor of Physics, a certificate of appreciation from the Division of Magnetic Fusion Energy, E.R.D.A., for "numerous and innovative contributions to the field of fusion research" . . . to **David**

D. K. McNear

F. R. Meyer III

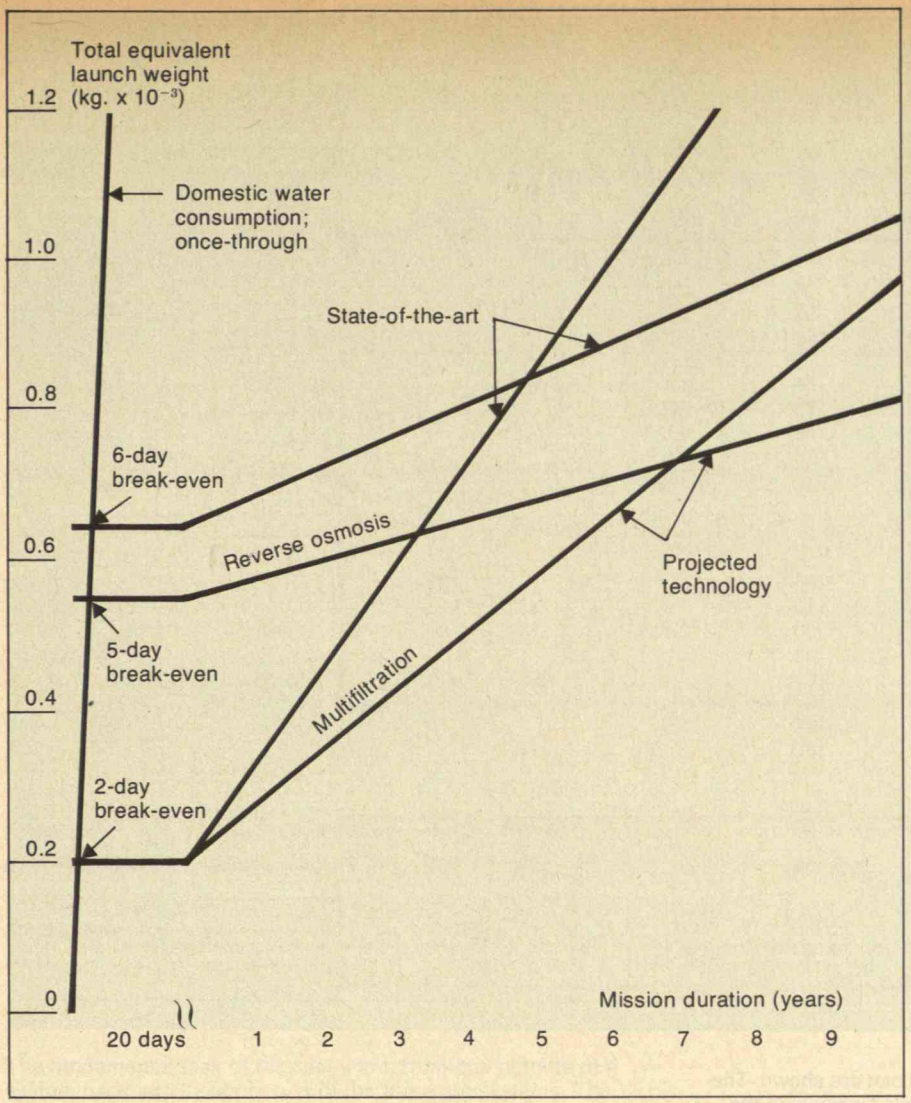
D. S. Saxon

Epstein, Professor of Music, a $3,000 Artists Fellowship in Music Composition from the Massachusetts Arts and Humanities Foundation . . . to **David Thorburn,** Associate Professor of Literature, a 1977 Rockefeller Foundation Fellowship in the Humanities.

Deceased

Mrs. L. Wallace Sweetser, '02; January 7, 1976; 39 Cedar Ln., Cheshire, Conn.
Henry A. Buff, '05; February 11, 1976; Hemlock Homestead, Barnstable, Mass.
Herman Eisele, '05; March 26, 1977; 7588 Mountain Park Dr., Mentor, Ohio
James B. Packard, '07; March 21, 1977; 26 Orchard St., Leominster, Mass.
Karl R. Kennison, '08; April 30, 1977; 29 Central St., Auburndale, Mass.
A. Sidney DeW. Herreshoff, '11; May 7, 1977; 125 Hope St., Bristol, R.I.
William T. MacCreadie, '11; November 13, 1975; 410 21st St., Box 67, Lewisburg, Penn.
Jesse F. Hakes, '12; October 4, 1976; Glenwood, N.J.
Mrs. Clinton E. Pearce, '13; April 27, 1976; 19811 Greenwood Pl., Seattle, Wash.
Mrs. Geoffrey M. Rollason, '13; March 30, 1977; 935 Belvidere Ave., Plainfield, N.J.
Elmer E. Dawson, Jr., '14; February 13, 1977; 89 Crofeet St., Pittsfield, Mass.
Perry R. F. Marshall, '14; May 8, 1977; 680 Cowles Rd., Santa Barbara, Calif.
Arthur P. Shepard, '14; October 13, 1975; 214 8th St., Hicksville, N.Y.
Mrs. William E. Brown, '15; 1976; 105 Old Farm Rd., Burlington, Vt.
Edward S. Jenkins, '16; April 16, 1977; 4949 Canterbury Dr., San Diego, Calif.
Thomas F. McSweeney, '16; February 8, 1977; 7 Triphammer Rd., Hingham, Mass.
James H. Murdough, '16; March 11, 1977; 2317 18th St., Lubbock, Tex.
Thomas E. Raymond, '16; August 30, 1974
William Wyer, '18; February 22, 1977; Indian Terr., Locust, N.J.
Maurice E. Goodridge, '19; September 28, 1976; 37 Old English Rd., Worcester, Mass.
Clyde K. Hall, '20; November 4, 1976; 728 No. Casey Key Rd., Osprey, Fla.
Alden W. Miller, '20; March 27, 1977; 1019 W. Mission Ln., Phoenix, Ariz.

Julius Wolozin, '20; May 27, 1977; 200 Mountain Ave., Malden, Mass.
Francis B. Kittredge, '21; May 24, 1977; 56 Academy Rd., North Andover, Mass.
Dr. Ronald G. MacDonald, '22; May 9, 1977; 3335 85th St., Jackson Heights, N.Y.
David R. Shotwell, '22; July 16, 1976; R. D. 3, Reading, Penn.
Mrs. Dudley Tait, '22; October 29, 1976; 9 Regua Pl., Oakland, Calif.
Thomas F. Williams, '22; January 29, 1977; 44 Crestwood Dr., Schenectady, N.Y.
Myron K. Chandler, '23; May 30, 1977; R. F. D. #4, Waldoboro, Maine
Harry D. Wolfe, '23; March 28, 1977; 401 New Castle Way, Madison, Wis.
Vincent E. Lysaght, '24; January 31, 1977; 70 Paine Ave., New Rochelle, N.Y.
Robert M. Simonds, '24; September 14, 1976; Apaquogue Rd., East Hampton, N.Y.
Henry Chippendale, '25; April 4, 1977; Apt. 12R, 31 Woodland St., Hartford, Conn.
Edward Zetterberg, '25; April 27, 1977; 1101 North Jefferson St., Muncie, Ind.
Lyman Billings, '26; May 15, 1977; 156 Chestnut St., North Andover, Mass.
Lewis M. Lucas, '26; May 6, 1977; 155 Brester St., #5M, Bridgeport, Conn.
Thomas W. Moore, '26; April 18, 1977; 5934 Shady River Rd., Houston, Tex.
George C. Popps, '27; January, 1977; 7723 Roctn Ave., Chevy Chase, Md.
Terry A. Hurlbut, '28; January 18, 1977; 1124-B Argyll Ave., Lakewood, N.J.
William S. McClintic, '28; March 28, 1977; P.O. Box 461, Hot Springs, Va.
Owen W. Rideout, '28; December 1, 1976; 10 Ledyard Ln., Hanover, N.H.
Graydon Smith, '28; August 14, 1976; 21 Lexington Rd., Concord, Mass.
George N. Wedlake, '28; 1976; 23 Lincoln Ave., Brantford, Ontario, Canada
Alfonso Tammaro, '29; 1976; One Jackson Walkway, Providence, R.I.
George E. White, '29; September 11, 1976; 3401 Gulf Shore Blvd., #301, Naples, Fla.
Frank M. Gager, '30; April 5, 1977; 4006 Queensbury Rd., Hyattsville, Md.
George F. Schatz, '30; March 2, 1977; Star Rt 330-C, Whispering Pines, Payson, Ariz.
Jack O. Wilkinson, '31; March 6, 1977; P.O. Box 23, Travernier, Fla.
Erskine G. Roberts, '32; December, 1976; 5471 S. Hyde Pk. Blvd., Apt. 7B, Chicago, Ill.
Gorham Cluett, '33; December 4, 1976; Moonpenny Ln., Chatham, Mass.
Benjamin S. Malin, '34; March 27, 1977
Robert J. Anderson, '35; May 1, 1977; 7312 Biltmore Dr., Gulfgate, Sarasota, Fla.
Louis E. Garono, '35; April 4, 1977; Rt. 1, Box 14, Darlington, Md.
Richard C. DeLong, '38; May 5, 1977; R. R. 3, Box. 62-A, Huntington, Ind.
Wendell F. Jacques, '39; May 30, 1977; P.O. Box 331, Hyannisport, Mass.
Howard Carson, '40; February 26, 1975; Cadillac Gage, 1750 Whittier Ave., Costa Mesa, Calif.
Robert H. Hose, '40; March 30, 1977; 4 Park Slope, Mountainside, N.J.
Capt. Morton Sunderland, '41; January 16, 1973; 219 Old County Rd., Severna Park, Md.
Richard L. Carter, '44; May 12, 1976; Rennselaer Polytechnic Institute Department of Management Engineering, 110 Eighth St., Troy, N.Y.
Earle O. Turner, '44; June 2, 1977; Box 32, Harvard, Mass.
John J. Barrett, '47; April 12, 1977; 23 Gordon Rd. Needham, Mass.
Hugh B. Morrison, '48; February 21, 1977; 7 Sycamore Ln., Skillman, N.J.
Franklin G. Fagan, Jr., '50; 24 Oakbrook Rd., Ossining, N.Y.
John A. Gorton, '50; March 28, 1976; 414 McKennans Church Rd., Wilmington, Del.
John M. Main, '50; 11919 Gravely Lake Dr., Tacoma, Wash.
Edward M. Stone, '51; April 3, 1977; 156 Berkshire Manor, 2060 Continental Ave., Tallahasee, Fla.
Robert C. Lynch, '52; April 4, 1977; 28 MacArthur Blvd., Danvers, Mass.
Benny B. Mathias, '52; August 15, 1975; 1022 Scribner St., Maumee, Ohio
Kenneth R. H. Read, '56; February, 1977; 1007 Lowell Rd., Concord, Mass.
Mauricio A. Borgonovo, '61; May 10, 1977, Edificio Comm. San Salvador, El Salvador
Seymour L. Cromwell, '61; May 2, 1977; Box 181, Bridgehampton, N.Y.
James C. Stuard, '67; May 25, 1977; 93 Waltham #4, Roxbury, Mass.
Robert C. Jones, '70; January, 1975; 77 Rachelle Ave., Stamford, Conn.



Two methods of recycling domestic water for a six-person crew are shown here. For state-of-the-art technology, it is less costly to use the reverse osmosis (RO) system for recycle if the flight lasts more than six days. Multifiltration is more attractive for flights lasting less than four to six years, although the cross-over to RO occurs at proportionately shorter durations as the crew size increases.

not vary by more than 25 per cent, but some specific amino acids varied by a factor of two.) Changes in mineral content were not major (with potassium in carrot and turnip being the exception), but again these differences were not significant. On the other hand, the trace elements showed considerable change, aluminum having the largest variation. Since the physiological effects of trace elements in humans is still somewhat ill-defined, a significant amount of research will probably be required in plant physiology, analytical chemistry, and human physiology of trace elements. Furthermore, the materials used in the construction of the life support system will have to be carefully selected since minuscule rates of corrosion can lead to significant build-up of trace elements in the food chain over long durations. Separation of mixtures of metallic elements and subsequent refining and recycle is one of our major earth-based problems of today and it will have similar if not greater urgency in a space colony.

One of the most worrisome unknowns is the long-term effects of restricted diets. It is clear that the varieties of foods in space will be very limited relative to that on earth. Although there are many remote cultures that exist on restricted diets, these people have had centuries for their bodies to adapt. The nutritional requirements that have been determined for our society address rather broad categories. In fact, the essential ingredients have become known, usually in retrospect, when a lack of them in some variation of diet creates a problem. Thus, we must account for the possibility of some new types of scurvy to arise over time in the space colony.

Finally, one of the most challenging problems and perhaps the key pacing technology relates to the toxicology and microbiology of the space colony. It is well known that metabolic wastes of one living species can be toxic to other species and even to itself, if the concentration exceeds certain limits. Furthermore, elements of the microflora which coexists synergistically within or in the immediate surrounds of each species can have deleterious effects on other species. We speak here in rather general terms of toxins and bacteria because specific identification of the bad actors is an extremely complex task. Two examples from the Bios-3 experiments illustrate this point.

During a 73-day chamber test including compartments for one man, phytotron, algae, and microbe cultivators, the plant growth rate deteriorated, the wheat crop being hardest hit. Although the nature of the crop failure was not conclusively identified, the investigators speculated that it was probably the result of accumulation of plant

Food	Grams	Approx. measure	Energy (calories)	Protein (grams)	Raw materials (grams) Milk	Meat	Eggs	Grain	Veg. & fruit
Foundation diet[1] (1250 calories)									
Milk	488	16 oz.	330	17	488				
Meat	100		295	24		100			
Eggs	50	1 med.	80	6.5			50		
Vegetables:									
Deep green or yellow	100	½ cup	30	2.0					100
Potato	100	1 med.	93	2.6					100
Other	100	½ cup	42	2.1					100
Fruits:									
Citrus or tomato	185	6 oz. juice	55	1.1					185
Other	100	1 serving	75	0.7					100
Bread[3] (white)	70	3 slices	180	6.0	93			40	10
Cereal (whole grain)	30	⅔ cup	70	1.8				30	
Subtotals	1,323		1,250	64	581	100	50	70	595
Supplemental diet[2] (1150 calories)									
Meat	100		295	24		100			
Fruits	150		113	1.1					150
Bread[3]	23	1 slice	60	2.0	31			13	3
Sugar[4]	24	2 tbsp.	96						192
Butter[5]	21	1½ tbsp.	150		420				
Mayonnaise	14	1 tbsp.	100				4		
Cookies (oatmeal)	28		126	2.0			2	8	144
Pudding	100		132	3	127		16		56
Soft drink	170		78						
Coffee or tea	360								
Subtotals	990		1,150	32	578	100	22	21	545
Totals	**2,313**		**2,400**	**96**	**1,159**	**200**	**72**	**91**	**1,140**

[1] Foundation diet from Bogert, 1973
[2] Supplemental diet from Young, 1977
[3] White bread recipe from Beard, 1959
[4] Assumes sugar from beets at 8 g beets/g. sugar
[5] Assumes 20 g whole milk/g butter

The typical components of an American adult's diet are shown. The five columns at the right show the raw materials from which the foodstuffs would be made.

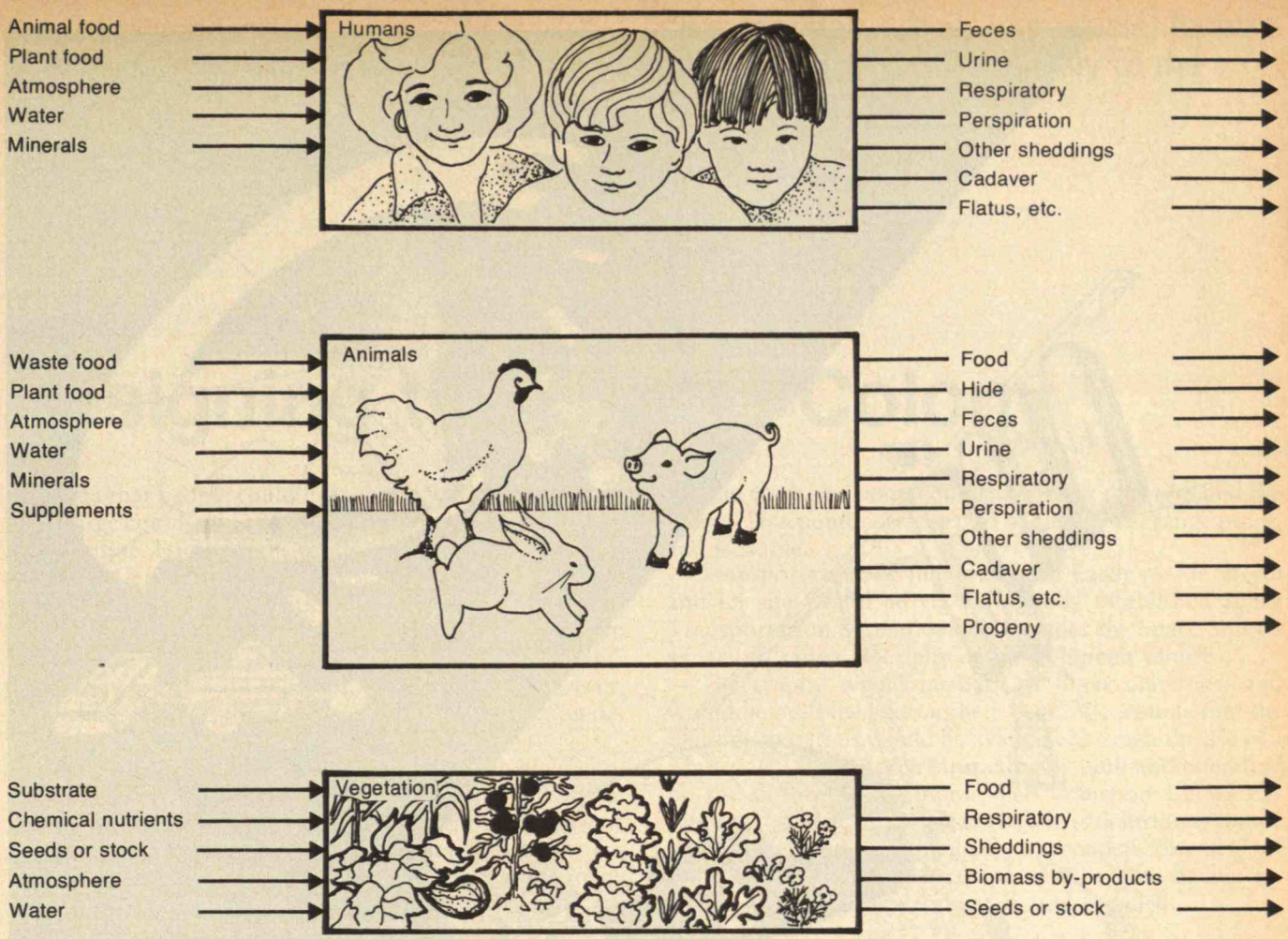
metabolites of the accompanying microflora in the nutrient medium. Although the plants were grown without a substrate, a massive growth of algae was noted on the plant roots.

In the 180-day test with three crew members, it was noted that when the phytotron was connected to the Bios-3 system, toxicity of the atmosphere of the system (man plus *chlorella*) to plants was noted. Growth of young potato and tomato plants stopped and cucumber leaves turned yellow. After disconnecting the phytotron from the system and ventilating it with normal atmosphere, the signs of poisoning completely disappeared within days. Reconnection of the phytotron to the system gave the same pattern of toxification. The toxic principle was not identified nor was its source determined.

Future Directions

Lack of knowledge and fear of the unknown has not stopped our society in the past and it probably will not stop us in the future. However, we probably should (and I expect we will) proceed with caution. Although it is hard to envision the launching of a large colony for a long-duration mission within the next 25 years, it might be well to think in terms of an earth-based CELSS laboratory within the next 10 to 15 years. An underground, closed ecological laboratory might evolve as a research center for controlled growth of plants and animals. The research "colony" would have a sizeable critical mass since it would have to include an extensive analytical chemistry laboratory, a disease control center, as well as a complete medical hospital facility. Add to that the engineering component for waste treatment and recycle, and we are probably in the range of thousands of inhabitants.

The fall-out from such an earth-based CELSS laboratory could be extremely valuable and might justify the experimental facility on its own. Much of the agricultural research is needed in its own right. Learning how to close the recycle loop is clearly one of our major priorities in the decades ahead. As the nuclear club continues to expand, we will undoubtedly face nuclear threats in the future. Learning what it takes to survive a nuclear holocaust may well be one of the least expensive forms of self-defense.



The fundamental task of recycle is to turn all the outputs of a system back into inputs of one of the three subsystems. The fundamental inputs and outputs of a closed ecological life support system (CELSS) are shown.

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R. B. Jagow, "Development of a Spacecraft Wet Oxidation Waste Processing System," A.S.M.E. Publication 72-ENAV-3, Environmental Control and Life Support Systems Conference, San Francisco, August 14-16, 1972.

R. D. Johnson and C. Holbrow, "Space Settlements; a Design Study," N.A.S.A. Publication No. SP-413, 1977.

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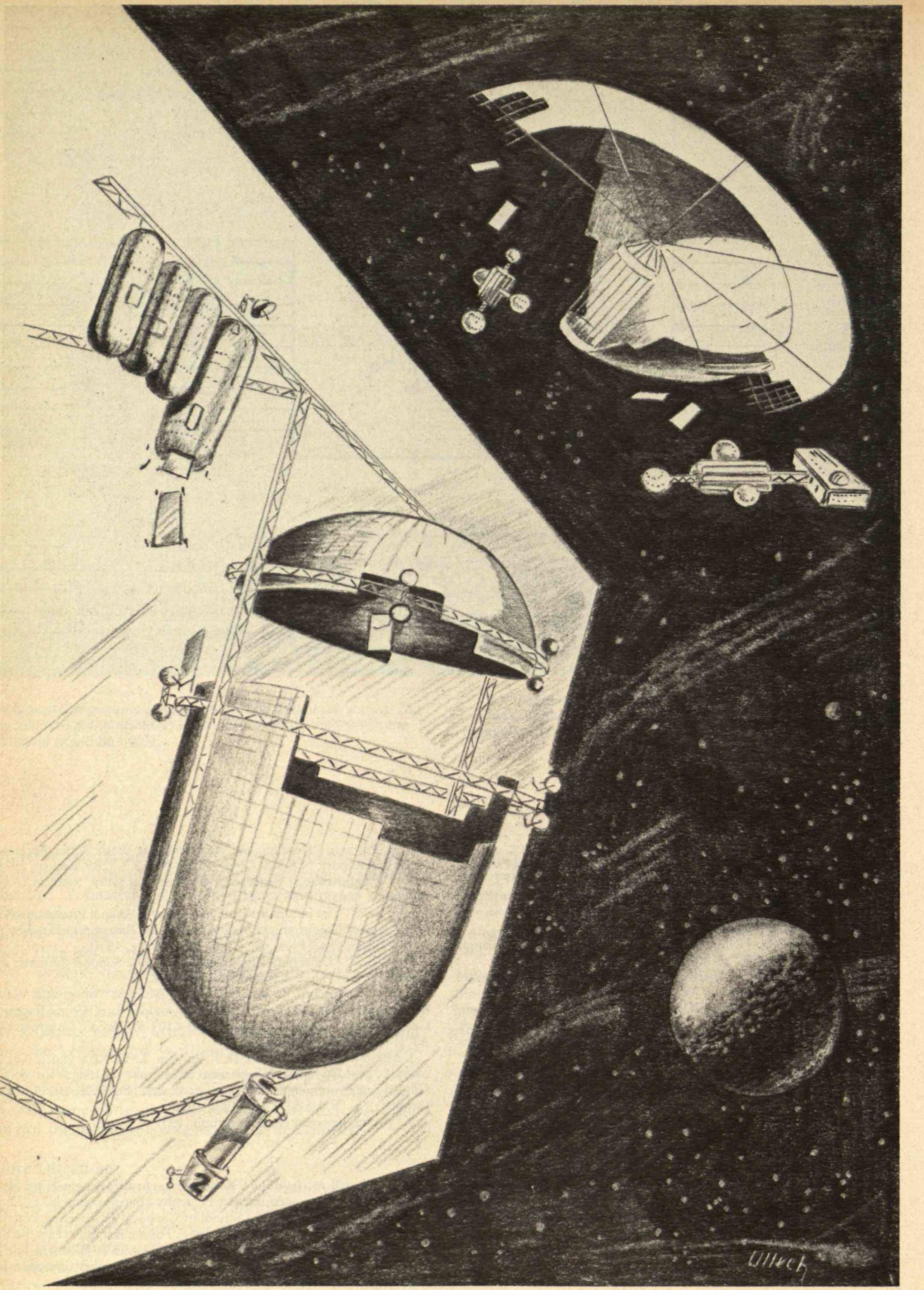

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"Engineering detail" is a crucial facet in determining the feasibility of the space colony concept.

Designing the Space Colony

The idea that people could live — and work productively — in large colonies in space was first suggested in 1911 by Konstantine Tsiolkovskij, the Russian rocketry pioneer. Recently Gerard O'Neill, the Princeton physicist, rekindled interest in the proposition with his article, "The Colonization of Space," which appeared in *Physics Today* in 1974. Since that time, many designs for "space habitats" have been proposed. Most of these designs, however, have shared the assumption that certain "engineering details" could be worked out.

Because it is just this "engineering detail" which actually determines the shape, function, and even feasibility of a space habitat, a clear need for a technical study existed. The following is, we believe, the first state-of-the-art engineering study of a prototype space colony, using many of the design and analysis methods currently used in the aerospace community for preliminary design.

But such a design study is only of speculative value unless an economic justification for the project exists. In the case of colonies, it is proposed that metal refining and materials processing in space, as well as the construction of large space structures such as satellite solar power stations, supply this economic justification. Should the cost of these processes, including of course the initial cost of establishing the space habitat and manufacturing facility, be shown to be economically feasible, the colony concept could become a reality.

The objective of our study was to investigate the engineering feasibility of a 1,000-person prototype colony. Our prototype is much smaller than other full-scale designs, yet larger than some already proposed earth-supported space stations. It is intended as the first step in demonstrating the viability of the colony concept. Since the design incorporates many of the features of larger colonies, it could be used to verify the technology of such space structures through a project of relatively (compared to larger projects) lower cost and more rapid investment return.

To limit our study to the actual design of the space colony, we made some initial assumptions:

— We assume our colony to be located in a stable orbit around earth at a point equidistant from the earth and the moon. This point is referred to as the L5 Lagrange point, and is stable.

— Transportation of material from earth to the moon and L5 site would be via the already established Space Transportation System, which includes the Space Shuttle as well as larger, specially designed launch vehicles.

— The colony would be built of lunar materials, and would be built in space at the L5 site. We assume that the building materials would be available through the use of a Transport Linear Accelerator, already built and operating on the surface of the moon. The Transport Linear Accelerator is basically a linear electric synchronous motor that accelerates a magnetically suspended "bucket" of lunar materials to lunar-escape velocity; the bucket releases its payload, is decelerated, and recycled.

The partially completed colony hull is assembled by cranes, while prefabricated sections used in the assembly are manufactured at work shacks (upper left). In the distance, the solar cells and parabolic mirror array are under construction. (Drawing: Robert Ullrich)

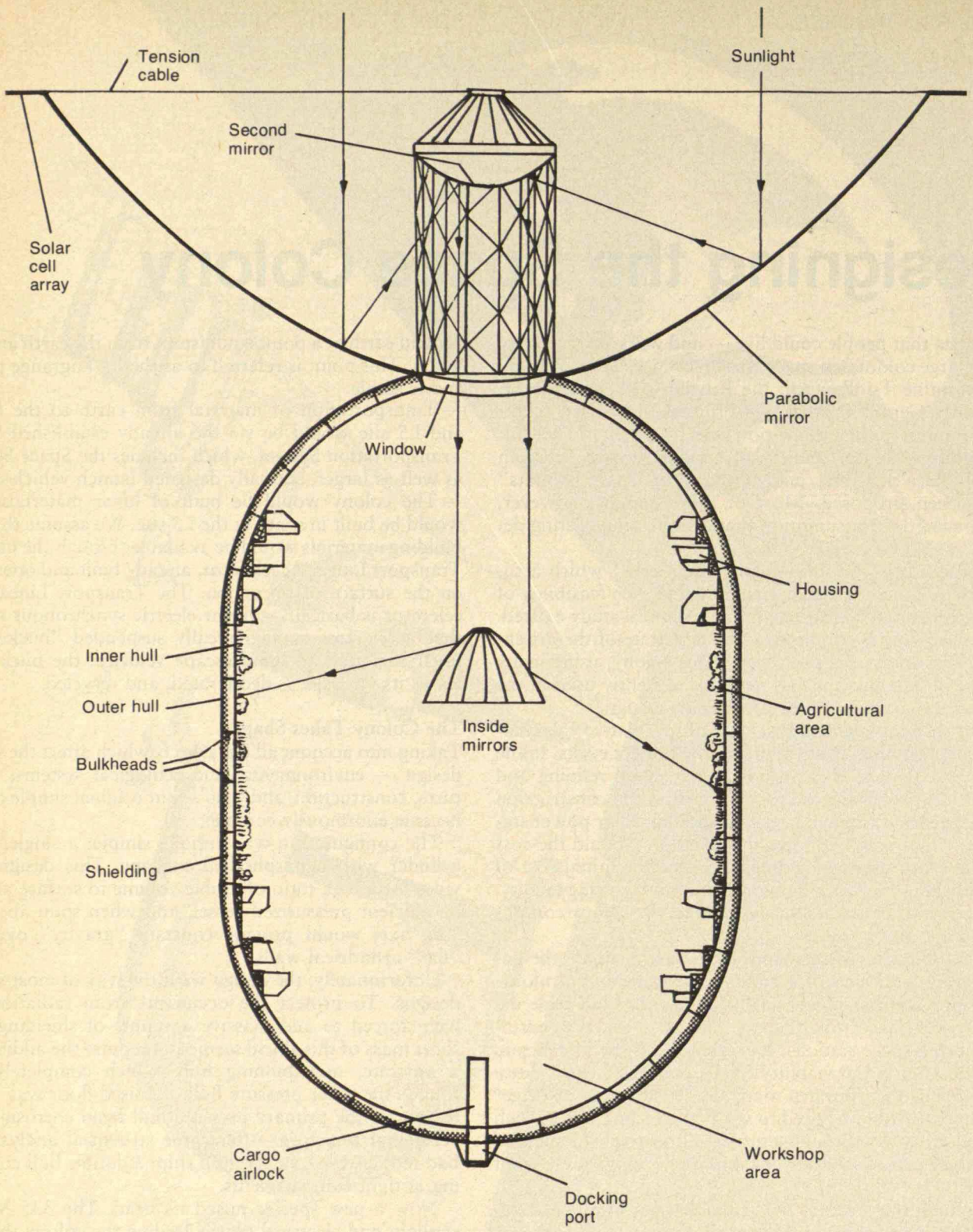
The Colony Takes Shape

Taking into account all the aspects which affect the actual design — environmental and ecological systems, structures, construction, and cost — our original simple design became enormously complex.

The configuration was initially simple: a single, short cylinder with hemispherical endcaps. This design provides for a high ratio of usable volume to surface area, is an efficient pressurized vessel, and when spun about its long axis would provide constant "gravity" over the "flat" cylindrical walls.

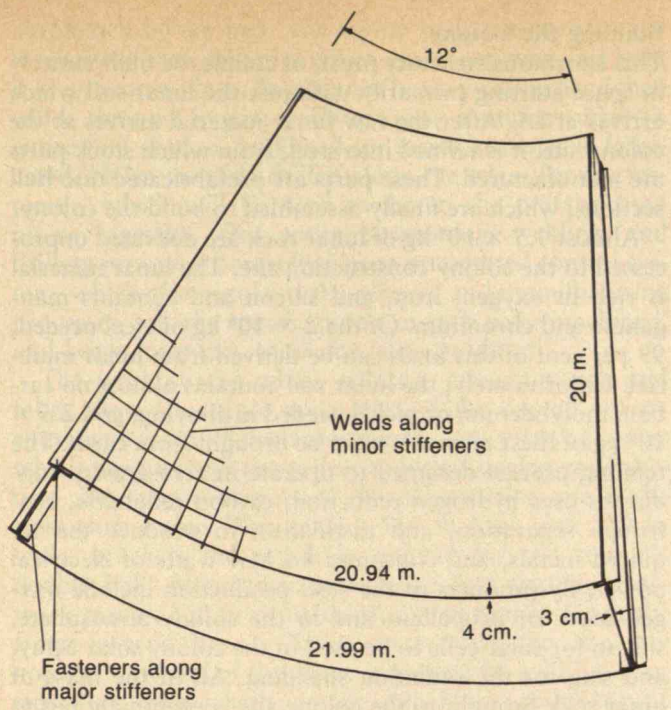
Unfortunately, the design went the way of most simple designs. To protect the occupants from radiation, we were forced to add massive amounts of shielding. The sheer mass of this shield seemed to require the addition of a separate, non-spinning hull, which completely surrounds the inner pressure hull. A raised floor was added to protect the primary pressure hull from corrosion and accidental puncture. After some structural analysis, we had rediscovered the modern ship: a double hull containing airtight compartments.

Now a new specter raised its head. The 335 Mw of sunlight and electrical power feeding the colony through its solar collectors and power plant was introducing a lot of heat into the colony. But since the inner hull was contained within an outer hull, separated by a vacuum, little or no heat could be radiated directly from the inner hull. We had inadvertently created an enormous space thermos bottle. Proposals to solve the problem, such as heat pipes or thermal conduction paths in the shield, merely compounded the complexity of the design, without offering hope of a complete solution.



Above:
This cut-away view of the colony shows that some of the incident sunlight falls on the solar cell array (top), while the remainder is used to illuminate the colony interior as it reflects from a set of mirrors inside the colony. Inside the double-hull colony, space is divided into housing, agriculture, and workshop areas. Access to the colony is through a docking port (bottom).

Opposite page, above:
The main building blocks of the colony hull can be seen in this sketch of a typical compartment from the cylindrical walls of the colony. The 20m x 20m inner and outer hull sections are welded together from one-meter-square plates separated by minor stiffeners. The hull sections and bulkheads are then fastened at their edges by the T-shaped major stiffeners.



Other distressing problems arose. The solar collector had to be kept facing the sun. There was the possibility of the rotating inner pressure hull colliding with the nonrotating outside radiation shield. Finally, we simplified the design.

A Fail-Safe Colony

The colony structure we determined to be most workable consists of two steel hulls separated at a distance of five meters by continuous bulkheads. The bulkheads, running longitudinally between the tips of the endcaps, and circumferentially around the hulls, form a distorted checkerboard pattern of 510 airtight compartments. Stacked in each of the roughly 20m x 20m x 5m compartments is a 2.5m-thick layer of bagged lunar soil and slag with a mass distribution of 5,000 kg per square meter. This layer shields against solar and galactic radiation. The radiation level inside the colony is roughly twice that of normal earth background radiation, below all present maximum limits for long duration radiation exposure.

This double-hulled compartmentalized design evolved from the lifetime requirements and operating conditions a colony must endure. The prototype colony was designed for a safe life of 30 years of continuous operation. During its operation, the spinning of the colony in the vacuum of space creates not only simple static loads but also dynamic loads which must be carried by the colony structure. Under these loads, no major structural damage can be tolerated in the colony's 30-year lifespan if the colonists' safety is to be insured. If minor damage occurs, repairs must be made easily in the space environment, without interrupting the smooth operation of the colony. To achieve this 30-year lifetime, the "fail-safe" and "leak-before-break" structural design criteria were used.

The leak-before-break criterion sets the minimum thickness of the steel plates used in the hulls. The steel plates must be thick enough so that any crack which occurs will work through the plate and cause a leak before it propagates to cause plate failure. To detect the leaks, we devised a system of keeping adjoining compartments at differing air pressures. Just like the colors of any two adjoining squares of a checkerboard are different, so too is there a pressure difference between any two adjoining compartments of the colony hull. In addition, the pressure in any compartment is below that of the colony interior and above that of free space. A leak in any of the six walls of a compartment will therefore cause a change in pressure. With one pressure sensor in each of the 510 compartments, a crack anywhere in the structure can be quickly detected and isolated, not only to the compartment, but to the bulkhead or hull section of that compartment which contains the crack. The damaged plate can then be found, removed, and replaced.

Should damage be done by impact or explosion, the entire colony would remain intact due to the fail-safe nature of its design. In a fail-safe design, if any one structural element breaks, the neighboring elements are strong enough to take up the additional load without themselves yielding. In our case, at the edge of each 1m x 1m plate, there is a minor stiffener of a tougher material. If up to four adjoining lm x lm panels were lost, the damage would be localized by the minor stiffeners and no further failure would occur. In no event could a crack go further than the edge of hull section or bulkhead in which it started, since these pieces are bolted together. If any damage occurs, the remaining structure would hold together because of its fail-safe design.

In the event of puncture and depressurization within the compartment, both the inner and outer hull sections must be able to take the full pressure load of the two-fifths earth atmosphere of the colony interior. The compartments' small size minimizes the plate bending stresses which would occur in such a case. Because the inner and outer hulls must be strong enough to withstand these pressure loads, the radiation shielding material can be included between the inner and outer hull with little weight penalty. This structural design, therefore, not only insures the 30-year safe life of the colony and its inhabitants, but permits inspection and repair schemes which require only simple technology and do not interfere with normal colony operations.

A View From Outside

From the outside, our colony is seen to consist of three large parts: the flat, sunlight-collecting mirror; the large shadow reflector; and the colony itself.

The mirror and reflector are both simple trusswork structures. The flat elliptic mirror redirects the sunlight onto the colony's solar cells and parabolic mirror. The rectangular shadow reflector shades the colony from direct sunlight, and thus acts to help regulate temperature. Both are kept in place by small rocket thrusters at a distance sufficient to avoid interference with thermal radiation from the colony.

The double-hull colony, consisting of the 100-meter-long cylindrical section with an outer radius of 105m, capped by hemispherical endcaps, supports all life. At the tip of one endcap, a docking port provides access to the colony interior through an air lock. Both docking port and air lock are sized to handle a space shuttle payload.

At the opposite end are the colony's two energy systems. The outer beams of the reflected sunlight from the elliptic mirror impinge on the colony's annular solar cell array, which generates 9.35 Mw of electric power. The

inner beams fall on the parabolic mirror, which concentrates the sunlight on a second mirror. The light passes through a window 40m in diameter as concentrated parallel beams, and is dispersed by a set of inside mirrors onto the colony's agricultural area, thus providing direct or diffuse controlled sunlight to all parts of the colony interior.

The colony hull is oriented so that it spins at two or three revolutions per minute about its long axis, perpendicular to the plane of the earth's orbit about the sun. This spin provides a pseudogravity of 0.5g to 1.0g on the inner walls of the hull in the cylindrical section. Since neither the long-term physiological effects of low gravity or of continuous spinning are well established, the colony is designed so that it can spin at different rates during its lifetime. Thus the effect of spin and low gravity can be studied in a controlled long-duration space environment.

As was mentioned, the colony is located at the L5 Lagrange point, a point in orbit around the earth which forms an equilateral triangle to the moon and the earth. If one considers only the orbit of the colony around the earth (the two-body problem), then any object in orbit at the moon's radius and with the moon's velocity would be in stable equilibrium. However, the gravitational influence of the moon allows only a limited number of points of equilibrium in the earth-moon system. A colony built at L5 would stay at this fixed point.

Life in the Colony

In all elements of colony planning — environment, housing, and food — we attempted to provide as close to an earth-like lifestyle as possible for the colonists. After the construction is completed, the colony will be populated by a representative mixture of men and women of all ages, both single and married, and might include children. Inside the colony, the atmosphere which the colonists breathe is an equal mixture of nitrogen and oxygen at two-fifths earth sea level pressure. This mixture provides the same partial pressure of oxygen as is found on earth, and enough nitrogen to retard combustion. The climate is maintained at 72° F and 60 per cent relative humidity by a system which recirculates the total atmospheric volume every 20 minutes. The thermal balance is maintained by transferring the heat gain of the colony (33.5 Mw from sunlight and electrical consumption) in the form of warm air to a refrigerant. The refrigerant then circulates to warm the outer hull, which in turn radiates the waste heat into space.

Interior space in the colony is allocated into working, living, and food-producing areas. Workshops are located in low-gravity areas near the spin axis, to take advantage of low- and zero-gravity conditions for research and manufacturing of special products. The higher-gravity areas of the endcaps near the cylindrical section provide a "hillside" setting for living spaces for the 1,000 colonists.

Living spaces are arranged in a small community of townhouses, each with its own private outdoor space. Community facilities planned include administrative offices, shops, performing arts studios and auditoria, sports facilities, a hotel, hospital and places of worship.

Finally, the 62,800 square meters of land in the cylindrical section is used for agriculture. Covered with a 30 cm thickness of lunar soil enriched with a nutrient solution brought from earth, this area would yield the necessary meat, fruit, vegetables, grain products, milk and eggs for the colonists' diet.

Building the Colony

This enormous structure must, of course, be built entirely in space starting primarily with just the lunar soil which arrives at L5. After the raw lunar material arrives at the colony site, it is refined into steel, from which stock parts are manufactured. These parts are prefabricated into hull sections, which are finally assembled to build the colony.

Almost 1.5×10^9 kg of lunar rock are delivered unprocessed to the colony construction site. The lunar material is rich in oxygen, iron, and silicon and contains manganese and chromium. Of the 2×10^8 kg of steel needed, 99 per cent of this mass can be derived from lunar material. Unfortunately, the lunar soil contains almost no carbon, molybdenum or nickel needed in alloying, and 2.5×10^6 kg of these elements must be brought from earth. The refining process designed to operate in zero-gravity conditions uses hydrogen reduction, carbon reduction, centrifuge separation, and distillation to produce the required metals, and consumes 46 Mw watts of electrical power. By-products of the steel production include oxygen used for propellant and in the colony atmosphere, silicon for solar cells to be used in the colony solar array, and slag for the radiation shielding. All of the mass of lunar rock brought to the colony site is eventually put to use.

The one-ton steel ingots produced by the refinery are manufactured into stock parts for the colony by a sequence of industrial machinery. The ingots are rolled, drawn, and cut until the pieces are small enough to be machined to final dimensions. The size, weight and design of the machines used in this process are taken directly from existing earth-based industrial equipment. "Heavy" equipment designed for operation in space could probably be made lighter and more efficient, since it operates in the absence of gravity. However, since no work has been done on the design of such equipment for space, the full-size, present-day equipment was used as a baseline design. An interesting result of the study was the discovery that machine tools ranging in size from drill presses to rolling mills all tend to have an average density based on the overall volume they occupy of 500 kg/m^3, and a specific power consumption of 3 watts/kg. The final output of stock parts from the manufacturing process over the estimated five years of colony construction is staggering: 600,000 1m × 1m hull and bulkhead plates, 1,200,000 1m long minor stiffeners, pieces for 3,090 major stiffener assemblies and 3,353,000 nut-and-fastener pairs!

The next step in the operation is the prefabrication of the three basic types of building blocks which go into the assembly of a typical hull compartment: the 20m × 20m inner and outer hull sections; the four 5m × 20m bulkhead sections; and the major stiffeners which connect them by means of threaded mechanical fasteners. Each of these elements is prefabricated at the colony site in a special work shack. The prefabricated hull components are assembled from 1m × 1m panels of AISI 4130 steel, a standard high-strength structural alloy. The plates in the hull sections and bulkheads are separated from one another by minor stiffeners of HY-100 steel, an extremely tough alloy used in the construction of submarines. The steel plates used in making the hull sections are 4 cm thick, while the plates used in the bulkheads are 3 cm thick.

One large section is made at a time. One by one the small stock parts (minor stiffeners, plates, etc.) are taken by a mechanical manipulator arm and positioned over an

automated lay-up bed. The lay-up beds consist of many mechanical manipulators which grab each part and hold it in its proper place. An electron beam welding head then welds the part in place. The process continues until an entire hull section, bulkhead, or major stiffener is fabricated. Holes are then drilled along the edges for the fasteners, which will be used to fasten the prefabricated pieces together. This entire positioning, welding, and drilling process is controlled by an automated control system, which also regulates the refinery and manufacturing processes, sets the specifications on each piece machined, and keeps inventory of all the parts produced.

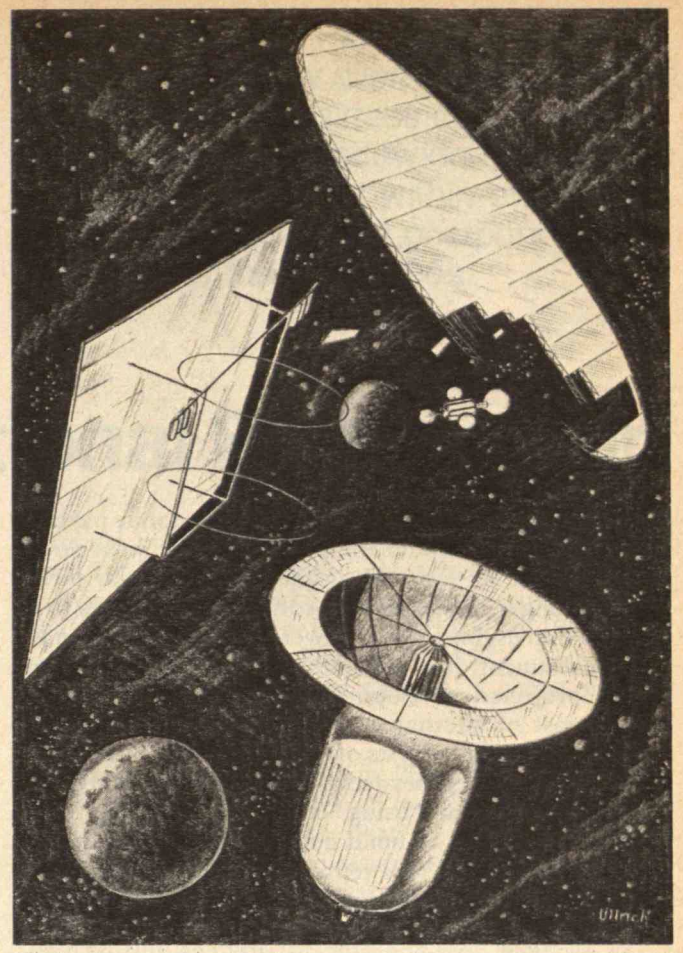
The work shacks where refining, manufacturing and fabrication take place are a part of the overall colony construction site. Aside from the 60 Mw solar cell array which produces all the power required during construction, the largest element of the construction site is the trusswork frame. This frame, 310 m long and 220 m wide, brackets the assembly volume for the colony's double hull. Along this frame move two circular trusswork cranes, 220 m in diameter, whose motion along the frame sweeps out a cylinder surrounding the assembly volume. One end of the frame is formed by a 400-m long trusswork mast, which provides attachment points for the crew's living quarters and the construction shacks. Along this mast runs a hoist to provide local transportation for people and material between the living quarters, assembly volume, and work shacks.

Once this construction site is deployed, colony construction proceeds. Lunar material arrives at the work shacks, where refining, manufacturing and fabrication take place. The 20m × 20m hull sections and 5m × 20m bulkhead sections produced in the last work shack are grabbed by manipulators on the hoist, moved along the mast, and transferred to a crane. The crane moves the section to its assembly point and positions it while workers fasten it in place. Once the hull is completed, the parabolic mirror, the solar cell array, and docking port are added and the construction apparatus is detached from the colony and moved away. The work force employed at the site builds from an initial crew of 50 people to a peak of 160 workers during assembly.

Before the arrival of the inhabitants, the quality of colony structure must be guaranteed. During manufacturing and after assembly, each component is inspected for flaws by ultrasonic and electromagnetic techniques, and samples are sent to earth for proof testing. To supplement these component inspections, the completed structure is also given two proof tests: over pressure and over spin. Only after these tests are completed, and detected failures are repaired, does the final pressurization, spin up, and installation of interior structures and agriculture take place, leaving the colony ready to receive its first inhabitants.

Scheduling and Costs

The program schedule developed for the prototype space colony project includes not only the period for construction itself, but also allows for the research, development, and initial deployment which necessarily precede construction. The schedule for the overall program falls rather naturally into four divisions: research, development, and procurement; construction site setup; colony construction; and testing, spin-up and interior finishing. Starting from program go-ahead, six years are spent in research and development of new systems, such as the colony structure and Transport Linear Accelerator. The orbital transfer and lunar landing vehicles are built and deployed at the end of this first phase. During the next three years, the lunar mining and transportation base is set up, and the colony construction site is deployed. The actual construction of the colony is ready to begin at the end of year nine, and extends over the next five years, with proof testing in the beginning of the program year 15. The remainder of that year and the next are spent outfitting the interior and starting the ecosystem. Thus overall colony completion is projected for the end of program year 16.



The colony construction site is shown being moved away from the completed colony hull with solar cell and parabolic mirror attached. In the upper right, the flat elliptical mirror which directs sunlight onto the solar cells in the parabolic mirror nears completion. (Drawing: Robert Ullrich)

The question of the total cost of the system is, of course, paramount to its potential acceptance and viability. We extrapolated individual costs on a system-by-system basis, based on cost information available on comparative systems already operational. Twenty-eight individual line items are identifiable; their costs in regard to research and development, production and procurement, and operations must be calculated. Costing for each item is then done on a year-by-year basis. In 1976 dollars, the overall prototype colony project is found to cost $64.5 billion, of which $13.7 billion are research and development costs, $6.6 billion are for procurement, and $44.1 billion are operational costs. The net future value at project completion, assuming a 10-per-cent discount

rate, is found to be $147.7 billion. The economic payback of this investment would come when satellite solar power stations, built on location, begin collecting solar power and beaming it to earth in the form of microwaves to be converted to usable electric power. While $148 billion is a large investment, it is not unreasonable when compared to the projected development, operating and environmental cost of alternative future energy sources. A detailed cost-benefit analysis of space-built solar power stations was, however, beyond the scope of our study.

We believe that, using current technology, it is technically feasible to build and operate a 1,000-person space colony at L5. This represents an evaluation of the engineering aspects of the design and construction of the colony structure itself, and does not address the related problems of the space transportation system and lunar base required for such an undertaking. Many other questions remain unanswered. Problems of human physiology, people's ability to adapt to a rapidly spinning colony environment, and the operation of the closed ecosystem must be better understood if the overall colony concept is to proceed.

An interesting specific conclusion of our research is that the colony is of a double hull design, built using 4-cm-thick steel plate, operating at low stress levels. This is very much unlike the light, highly stressed spacecraft structures designed to date, or other proposed colony designs, but is a result of a careful engineering analysis and the application of valid aerospace design criteria to the problem of colony design.

The colony could be built in 16 years from program approval at a direct cost of $64.5 billion. Discounting this cost, that is paying the 10 per cent compounded surcharge applied by the Office of the Management and Budget to aerospace programs, adds $83.2 billion for the total program cost of $147.7 billion. This schedule and cost is based on the assumed development of two future technologies: the Transport Linear Accelerator to propel materials for the colony from the moon, and a high productivity (66 kg/person-workhour) space processing facility to refine lunar rock into usable metals. If these two items could not be developed, the colony could still be built, but at a much higher cost. Thus we concluded that the construction of a prototype space colony for the purpose of space manufacturing and for the verification of the colony concept is technologically feasible from an engineering viewpoint, and deserves serious future consideration as part of an overall scheme for the industrialization and utilization of space.

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Author's Note

During the spring semester of 1976, 14 students enrolled in a course entitled Advanced Systems Engineering in the Department of Aeronautics and Astronautics. As students, we initially enrolled in the course for different reasons. Some of us were interested in taking part in a preliminary engineering design study, which is what the catalog said this course was supposed to offer. Others were primarily interested in the subject of this term's course, designing a space colony. Some were (and still are) quite skeptical of this space colony idea, while others were and are (almost literally) counting the days before the first colony is built.

We came together under the guidance of Professor John F. McCarthy, Jr., and Oscar Orringer, who quickly made it clear that this was to be a serious engineering endeavor, and that we ought to get down to business. We initially formed three groups: to study environment and systems; structural design; and fabrication and testing. Meeting several times a week for four months, the study was long enough so that the overall colony design evolved as a result of discussion and analysis and was not simply fixed at the beginning of the study. The experience was supposed to simulate a preliminary design group trying to do an engineering analysis and write a proposal under the pressure of a deadline. The pressure was simulated remarkably well, and after four months of intensive effort, we produced one of the first serious engineering analyses of space colonization.

Presented here is the final design of the M.I.T. Prototype Colony.

Edward Crawley received his S.B. in aeronautics and astronautics from M.I.T. in 1976. He is presently a graduate student working at the Gas Turbine and Plasma Dynamics Laboratory at M.I.T. under a fellowship from the Fannie and John Hertz Foundation.

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Carter's National Plan falls short of solving our energy dilemma. But it would buy us time. If business continues as usual, a severe, worldwide oil shortage could make itself felt within only five years. The Plan could postpone that shortage to the mid-1990s.

Evaluating the National Energy Plan

The nation's perception of its energy future has altered dramatically over the past five years. As late as 1972, U.S. energy policy was based on a vision of the future drawn unrealistically from past growth trends; energy consumption was seen as continuing to expand at historical rates, requiring increased domestic oil and gas production, more nuclear reactors, and rising imports to meet demand.

In 1973 the energy problem was thrown into graphic perspective. The Arab oil embargo brought home the vulnerability of this country's energy system to price increases in imported oil. Clearly, the U.S. could not continue to depend on this energy source to satisfy its demand. In 1975, the U.S. Geological Survey, under pressure from increasingly convincing evidence, lowered its estimate of the remaining domestic oil and gas resource base by a factor of six. Domestic gas and oil production had peaked in the early 1970s and now seemed likely to continue to decline. Demand for energy continued its upward spiral. A transition away from oil and gas to alternative energy sources was recognized as the only solution by which the U.S. could produce enough energy domestically to meet demand. Yet it was also clear that this transition could not be made overnight.

Today, the energy policy options open to this country must be weighed carefully, with full recognition of the difficulties inherent in the transition. Each possible alternative energy source — nuclear power, coal, synthetic fuels, breeder reactors, solar power — presents large problems as an immediate substitute for cheap, clean, convenient oil and gas. Technological, environmental, economic, and ethical questions must be answered about each option. The energy policymakers must somehow determine the trade-offs implicit in the support of one or more of these options, and choose a combination of policies which will assure adequate short- and long-term supplies. Furthermore, if the transition is to be smooth, energy policy must be directed not only toward increasing production, but toward decreasing consumption through strong energy conservation measures.

In 1975, members of the Dartmouth System Dynamics Group were contracted by the Energy Research and Development Administration to build an energy policy model. The model's purpose was to serve as a simulation device to evaluate the magnitude of the energy transition problem, and to assess the impacts of various energy policy options on the U.S. energy system. We recently applied the policy-testing capabilities of the model — FOSSIL1 — to evaluate the long-term effectiveness of the National Energy Plan introduced by President Carter on April 20, 1977. This report summarizes the results of our analysis, which focused on three specific questions:
— Can the National Energy Plan achieve its 1985 goals?
— How effective is the Plan after 1985?
— Could additional policies secure U.S. energy independence by 2000?

Analyzing the National Energy Plan

To evaluate the effectiveness of the National Energy Plan (N.E.P.), we compared the Plan to a Business-As-Usual (B.A.U.) projection, which assumed no changes in current energy policies. It is important to realize when judging these comparisons that the dates and numbers of quads cited in this analysis (or any long-term analysis accomplished with the aid of a model) are not absolute predictions — the large uncertainties involved in any such projection preclude that. They should be interpreted rather as indicators of the relative magnitude of change that can be expected from one projection in comparison with another.

In the B.A.U. projection, government policies remain at their current (June, 1977) status. Oil and gas prices continue to be regulated. (A ceiling price that returns 12 per cent per year to the oil and gas industries is enforced.) No new mandatory conservation programs are imposed — consumers conserve energy voluntarily in response to energy price increases. No new taxes or tariffs are initiated. No new environmental legislation is imposed and, perhaps as important, current environmental legislation — SO_2 standards and the 1969 Coal Mine Health and Safety Act — remains in force. E.R.D.A.'s Research, Development and Demonstration programs for advanced energy technologies are continued at their current scheduled pace. None of the policy options proposed in the N.E.P. is implemented.

The N.E.P. projection incorporates into the model the roughly 40 major energy policies comprising President Carter's Energy Plan (*see* The National Energy Plan, *Executive Office of the President, April, 1977*). The salient features of the Plan include policies meant to:
— increase energy conservation and fuel efficiency;
— raise the price of oil and natural gas;
— encourage conversion to coal;
— promote limited development of nuclear power; and
— stimulate the long-term development of renewable resources.

In general, the richness of the FOSSIL1 model's structure allowed us to capture the effects of specific policies

within the Plan in detail. Conservation policies were represented by enhancing the energy users' responsiveness to price changes. For the same price increase, consumers reduce their energy usage by a larger amount and switch to more energy-efficient end-use technologies. The Plan's fuel-specific energy tax packages were incorporated directly into the model structure, for FOSSIL1 energy prices are broken down by fuel type.

The myriad of regulatory restrictions concerning prohibition of new oil- and gas-fired utilities, scrubber requirements for coal-fired plants, strip mining legislation, bans on breeder reactors and commercial reprocessing and recycling, reductions in light-water reactor siting delays, and accelerated research and development in advanced energy technologies were also represented directly in the model structure.

We had difficulty identifying structural changes we could make in the model to represent the N.E.P.'s oil and gas pricing rules, which peg prices to fixed or target price levels (for example, $13.50 per barrel for new oil). While such levels may be perfectly appropriate in 1977 or even into the 1980s, they certainly cannot be expected to remain unchanged to the year 2000. The original FOSSIL1 B.A.U. pricing structure contains a flexible representation of regulatory pricing that adds enough profits to average oil and gas costs to allow the industry a fair rate of return (the historical total industry average of 12 per cent per year after taxes). In fact, this pricing structure projected oil and gas price paths that seemed representative of the N.E.P. pricing scheme. Thus our assumption is that the price increases called for in the N.E.P. would have occurred anyway under the B.A.U. The Plan clearly does not include any major structural changes in oil and gas pricing, such as deregulation.

Can the National Energy Plan Achieve Its 1985 Goals?

The National Energy Plan sets forth ambitious energy goals for 1985:

— To reduce the annual growth of total energy demand to below 2 per cent;

— To reduce gasoline consumption 10 per cent below its current level;

— To reduce oil imports from a potential level of 16 million barrels per day to 6 million, roughly one-eighth of total energy consumption;

— To establish a Strategic Petroleum Reserve of 1 billion barrels;

— To increase coal production by two-thirds, to more than 1 billion tons per year;

— To bring 90 per cent of existing American homes and all new buildings up to minimum energy efficiency standards; and

— To use solar energy in more than 2.5 million homes.

Because the FOSSIL1 model focuses only on the long-term interactions of the nation's energy supply and demand system, we limited our analysis to those three goals which address the system on an aggregate level — total energy demand, oil imports, and coal production.

Demand: Gross energy demand is reduced from 101 quads (10^{15} B.t.u.) per year in 1985 under B.A.U. to 94 quads with the National Energy Plan (*see p.55*). This represents a growth rate of 2.2 per cent per year, close to the President's goal of 2 per cent per year over this period. The decline in the rate of growth in demand is the result of N.E.P. policies which both raise the price of energy directly (stand-by gasoline tax, crude oil equalization tax) and also offer incentives for users to respond to price increases (gas guzzler tax and rebate, fuel efficiency standards). While the FOSSIL1 model is incapable of capturing the detailed response of consumer demand to price changes, our aggregate analysis indicates that the energy savings proposed as a goal for the country in the N.E.P. are within reach.

Oil imports: U.S. demand for oil imports increases to 35 quads (16 million barrels per day [m.b./d.]) in 1985, according to the model. With the implementation of the N.E.P., oil imports drop 8 quads to 27 quads per year (13 m.b./d.). This, while representing a significant savings, is still double the N.E.P. goal of 12 quads (6 m.b./d.). The difference lies in our estimates of petroleum production. While the N.E.P. goal assumes a modest *increase* in oil production (10 per cent) by 1985, the FOSSIL1 model projects that the current downward trend will continue, resulting in a net *decrease* in domestic petroleum production (to 11 quads or 5 m.b./d.). Almost all of the model's projected eight-quad decrease in oil imports under N.E.P. is accomplished by lowered demand, rather than by increased production.

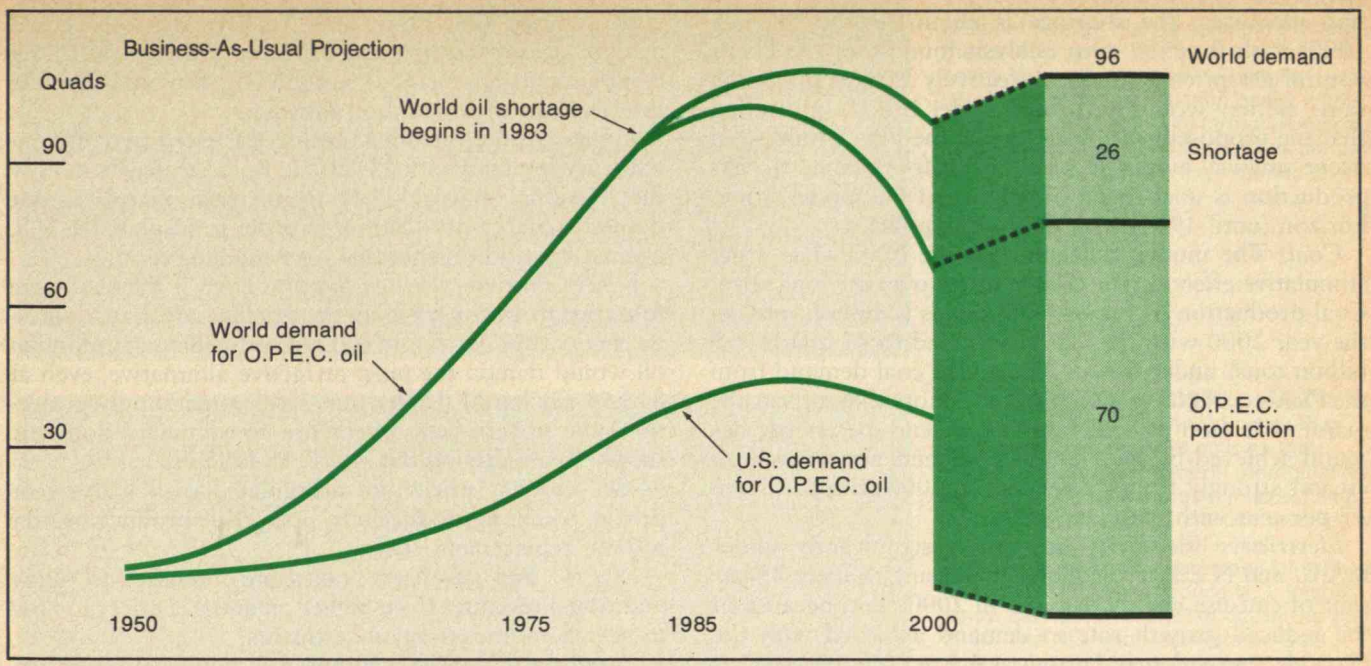
Coal Production: The N.E.P. sets a goal of increasing coal production to 1.2 billion tons per year in 1985. Our analysis suggests that coal production may fall slightly short of that goal, reaching 1.08 billion tons per year. The limitations to coal production result from demand constraints over the short term, when coal is used primarily as a boiler fuel in either the industrial sector or in electricity generation. While it appears possible to achieve the industrial usage goals with a major coal conversion program, coal usage in utilities falls about 150 million tons short of the N.E.P. goals by 1985. The utilities' demand for coal is limited by the reduction in electricity demand growth accompanying the N.E.P. (which limits the number of new coal-fired plants constructed in this time period), and by the restricted ability of existing plants to convert to coal.

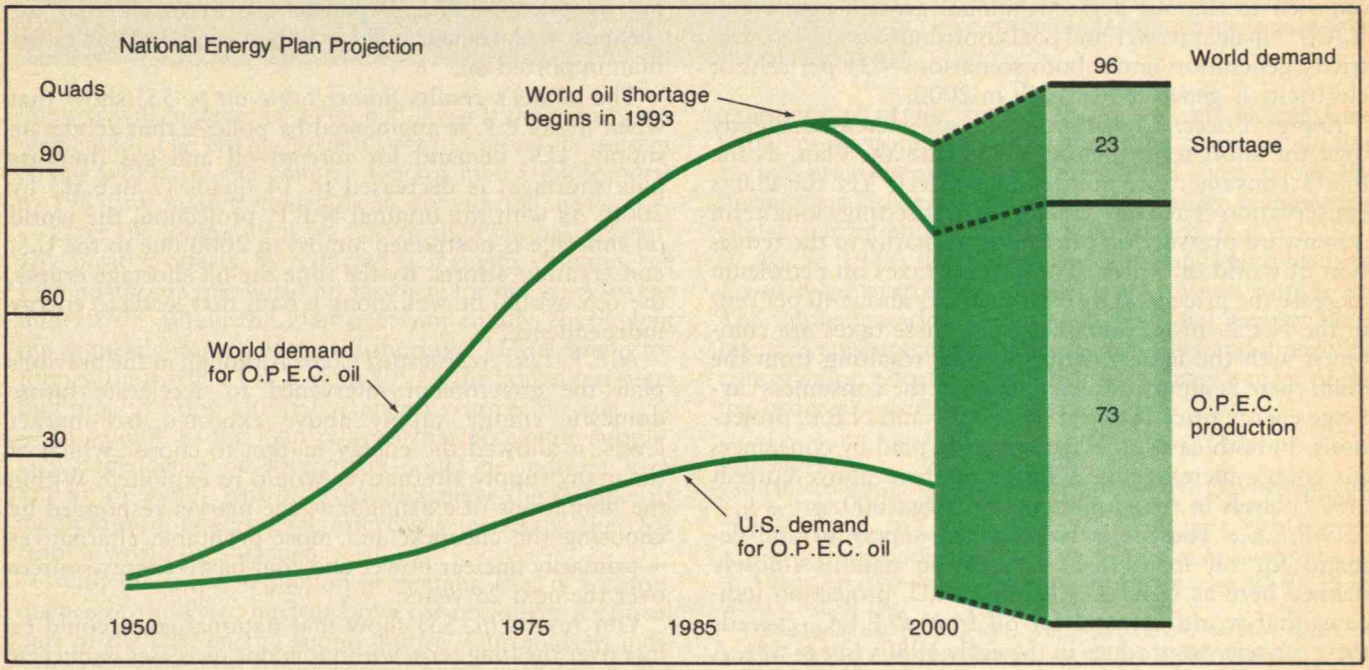
In summary, the FOSSIL1 projections suggest that although both the demand and the coal production goals set by the N.E.P. may be generally achievable by 1985, the Plan will fall short of attaining its most important goal: oil imports will rise to 27 quads (13 m.b./d.) in 1985 with the Plan, instead of dropping to 12 quads (6 m.b./d.). As disturbing as this discrepancy may be in the short term (up to 1985), it is even more critical over the long term. The FOSSIL1 model projects that a world oil shortage could begin in the early 1980s; a miscalculation in our level of dependence on foreign oil would dramatically increase the stress that such a shortage would place on the U.S. economy.

How Effective Is The Plan After 1985?

The FOSSIL1 model indicates that the U.S. is on a path toward increasing imports to 1985, no matter what policies are implemented today. Import levels in 1985 are now virtually beyond our control, because of the long time lags in the energy system. Yet, there is still time to shape the post-1985 future. The N.E.P. goes a long way toward improving the long-term energy prospects of the U.S., as our year 2000 analysis shows.

Demand: The projections of demand show that gross energy demand will grow up to 143 quads per year in the year 2000 under B.A.U., compared to 118 quads with the Plan. Energy demand grows at 2.5 per cent per year to the year 2000 under B.A.U., and only 1.8 per cent per year





In the FOSSIL1 Business-as-Usual projection, world demand for oil from the O.P.E.C. nations in the mid-1980s exceeds their capacity to produce. The large oil savings incurred from implementation of the National Energy Plan (as much as nine million barrels per day) is projected to postpone the world oil shortage for ten years, to the mid-1990s. This delay buys the U.S. ten additional years to decrease dependence on foreign oil and thus insulate itself from the direct effects of the shortage.

with the Plan. The N.E.P. package of conservation and energy tax policies therefore could reduce energy demand growth *below* the N.E.P. target level of 2 per cent per year over the long term. Yet even with reduced demand, the oil and gas burden is sizeable to the year 2000 — these fuels still must satisfy the bulk of U.S. energy consumption over the transition period (50 per cent by the year 2000 with the N.E.P.).

Oil: U.S. oil supply and demand are strongly affected by the policies of the N.E.P. The conservation and tax policies of the Plan reduce demand for oil by about 20 quads (9 m.b./d.) in 2000. However, the benefits of reduced oil demand are partially offset by the Plan's net depressive effects on domestic oil production (5 quads or 3 m.b./d. less in 2000). Domestic production is controlled largely by the world oil price over the next 25 years. The Plan's conservation programs lower U.S. demand for foreign oil (and therefore lower the world oil price) over the long term, resulting in reduced incentives for domestic production during this period. Although domestic production is lower, the net effect of the Plan on the oil sector is positive — U.S. demand for imported oil (oil imports plus shortage) is reduced 11 quads (5 m.b./d.) to 24 quads (12 m.b./d.) in 2000.

Gas: Because of the declining availability of gas, the U.S. would suffer a persistent, major gas shortage over the next 25 years with B.A.U. The N.E.P. policies cut down the severity of the gas shortage through conserva-

tion measures; the shortage is eliminated by the late 1990s with the Plan. Our analysis found that the Plan's natural gas pricing strategy effectively left gas prices the same as they would have been under B.A.U. (indicating that the proposed price increases of the Plan would soon occur anyway under B.A.U.). Therefore, domestic gas production is unchanged over most of the model's time horizon (until 1995) with the N.E.P. policies.

Coal: The model indicates that the N.E.P. has a net stimulative effect on the coal industry over the long term. Coal production increases to 43 quads (2 billion tons) in the year 2000 with the Plan, compared to 41 quads (1.9 billion tons) under B.A.U. The added coal demand from the Plan's coal conversion programs more than offsets the major reduction in coal's portion of end-use energy demand achieved by the Plan. U.S. dependence on coal increases strongly from 29 per cent in 2000 with B.A.U. to 37 per cent with the Plan.

Electricity: Electricity use grows significantly under B.A.U. and N.E.P. projections, increasing to meet 25 per cent of end-use energy demand in 2000. Yet, because of the reduced growth rate in demand achieved with the Plan, electricity demand grows at 4.5 per cent per year, as opposed to the 5.2 per cent annual growth rate under B.A.U. Nuclear power and coal contribute equally to electricity generation under both scenarios — 35 per cent of electricity is generated by each in 2000.

Energy Prices: Consumer prices are increased slightly over the short term (before 1985) with the Plan, as the Plan's consumer tax policies take effect. Yet the Plan's conservation package creates an offsetting long-term downward pressure on prices due primarily to the reduction of world oil prices. The various taxes on petroleum increase the price paid by oil consumers about 40 per cent in the N.E.P. projection. Yet when these taxes are combined with the lower world oil price resulting from the Plan, there is almost no net change in the consumers' average energy price between the B.A.U. and N.E.P. projections. In both cases, the average price paid by consumers for energy increases by a factor of three above current (1977) levels in real dollars by the year 2000.

O.P.E.C.: The projections for the supply of and demand for oil from the oil-exporting nations (loosely defined here as O.P.E.C.) in the B.A.U. projection indicates that world demand for oil from O.P.E.C. exceeds their capacity to produce in the early 1980s (*see p. 53*). A world oil shortage develops, even with steady expansion of O.P.E.C. production capacity (to 45 m.b./d. by 1985). The U.S. contributes significantly to the crisis; its share of total world demand for imports escalates from less than 20 per cent before 1970 to 35 per cent in 1985. As the shortage develops, the world oil price "breaks" from its current $13.50-per-barrel level, and begins to rise to the marginal cost ($25 per barrel) of oil substitutes.

Because the U.S. is likely to remain a major oil importer under the B.A.U., any reduction in U.S. imports could produce significant repercussions in the world oil market. The large U.S. oil savings projected with the N.E.P. (as much as 9 m.b./d.) do not avoid a world energy shortage entirely: this crisis seems inevitable given the limited resource base of the O.P.E.C. nations. Yet the N.E.P. postpones the world oil shortage from 1983 to 1993 in our simulations. This delay is crucial for the development of U.S. energy policy, buying the country ten precious years to bring alternative energy sources on line. If the strong conservation program of the N.E.P. were supplemented with policies that stimulated supply, the U.S. could achieve energy independence by the year 2000. Under these circumstances, the U.S. would be insulated from the direct effects of a world oil shortage.

In view of the previous results, we tested two alternative energy plans with FOSSIL1. Both strategies modify the National Energy Plan to increase incentives for domestic energy production, in order to insulate the U.S. against a world oil shortage over the long term.

N.E.P. Plus Accelerated Supply: Even if the U.S. were to return to free-market energy pricing, adequate domestic energy supplies would still not be forthcoming; foreign oil would remain the most attractive alternative, even at $13.50 per barrel. Under our Accelerated Supply projection, the government intervenes to stimulate domestic supply by modifying the N.E.P. as follows:

— Oil and gas prices are deregulated over a five-year period, to allow producers to price their products nearer to their replacement costs;

— No oil and gas users' taxes are imposed, to allow additional revenues from higher oil and gas prices to flow to new domestic energy investments;

— A substantial tariff is imposed in imported oil, bringing its price to $22.50 per barrel, to insure that the cheapest replacement will be domestic oil and gas rather than imported oil.

The model's results (*lower table on p. 55*) show that when the N.E.P. is augmented by policies that accelerate supply, U.S. demand for foreign oil and gas (imports plus shortage) is decreased to 14 quads (7 m.b./d.) by 2000. As with the original N.E.P. projection, the world oil shortage is postponed almost to 2000 due to the U.S. conservation efforts. By the time the oil shortage erupts, the U.S. would be well along a path that leads to energy independence.

N.E.P. Plus Accelerated Coal: Although in the previous plan the government intervened to accelerate future domestic energy supply above expected free-market levels, it allowed the energy market to choose which of the many supply alternatives would be exploited. Within the limitations of existing law, the market responded by choosing the cheapest and most profitable alternatives —primarily nuclear power and coal-based energy sources over the next 25 years.

Our results (*p. 55*) show that national goals could be met over the long term without major increases in nuclear power. Domestic energy production increases to 113 quads when the Accelerated Coal policies are added, a 13 per cent increase over B.A.U. Coal production increases to over 70 quads (3 billion tons per year) in 2000, and provides over 60 per cent of the nation's energy in that year. Total imports are reduced to 9 quads (4 m.b./d.), which is lower than the plans that included nuclear power. N.E.P. plus Accelerated Coal shows that an energy transition heavily based on coal could be considered as a feasible option.

Conclusions

Our analysis led us to the following conclusions:

— The National Energy Plan is first and foremost an energy conservation strategy, and as such we strongly endorse it. From our perspective, however, it does not go far enough — the Plan does not fully recognize the severity of the long-term problem.

— The Carter Administration's 1985 goal of a reduction in imports is overly optimistic. Our analysis projects that

		1976 Actual	1985 National Energy Plan Goals	Fossil1 Projections 1985 Business As Usual	1985 National Energy Plan
Gross demand	Quads/year:	77	96	101	94
Oil imports	Quads/year:	15	12	35	27
	Million barrels/day:	7.3	6	16	13
Coal production	Quads/year:	15	26	20	24
	Billion tons/year:	0.66	1.2	0.94	1.08

The FOSSIL1 projection of the impact of the National Energy Plan is compared to the Plan's 1985 goals. Although the Plan will nearly succeed in achieving both its demand and coal production goals, it falls short of its most important target: oil imports in 1985 will reach 13 million barrels per day under the Plan, double the intended level.

	Business As Usual	National Energy Plan	N.E.P. and Accelerated Supply	N.E.P. and Accelerated Coal
Gross demand	143	118	119	122
Domestic supply	100	89	105	113
Imports	30	23	13	9
Shortage	13	6	1	—

In the two additional FOSSIL1 projections, the policies of the National Energy Plan were supplemented with policies that accelerate supply in general (deregulation, tariff on oil imports, no user's taxes) and policies that accelerate coal use specifically (the previous policies plus a nuclear moratorium and loan guarantees for synfuel projects). Both plans reduce U.S. imports below the NEP level of 23 quads by the year 2000. The NEP plus Accelerated Coal projection indicates that national goals could be met without major increases in nuclear power. (All figures are in quads per year.)

imports will increase to 13 m.b./d. even if the Plan is implemented. The energy system's inertia along its present course will carry the country toward increasing imports to 1985, no matter what policies are enacted now.

— Over the longer term (to 2000), the Plan has measurable positive effects. By reducing U.S. energy demand, the Plan postpones the world oil shortage for ten years, to the mid-1990s. While the Plan does not totally circumvent the domestic impact of the oil shortage (U.S. demand for foreign oil is still 13 m.b./d. in 1995), the added ten years buy time to bring alternative energy sources on line.

— By adding to the Plan policies that accelerate supply, U.S. dependence on foreign oil could be reduced to 5 m.b./d. by 2000. This plan would achieve the President's medium-term energy goal, effectively insulating the U.S. from a world oil shortage.

— With the major reduction in demand that is a consequence of the Plan, nuclear power is no longer a critical part of the U.S. energy supply future. Our analysis indicates that even with a moratorium on nuclear power, the goals of the N.E.P. could be met by accelerating coal production and use. In fact, oil imports could drop even further to 4 m.b./d. when accelerated coal policies are added to the N.E.P.

Central to our analysis is the concept that there is a strong conflict between the economy's short-term and long-term well being. The policies that improve the long-term behavior of the energy system require significant short-term sacrifices by the American people — 1985 energy prices under the alternative energy plans are as much as 30 per cent higher than those in the Business-as-Usual projection. This prospect is not a popular one, for the country, its leaders, and individual consumers already feel the serious side-effects of rising energy prices. Yet over the long term, there is little doubt that the benefits of a National Energy Plan will more than offset its short-term costs. Many studies have come to refer to their Business-as-Usual projections as "surprise-free," indicating that these scenarios conform to most people's current expectations of the future. However, our Business-as-Usual projection is full of unpleasant surprises. Major energy price increases seem inevitable, even under the Business-as-Usual scenario. Moreover, there is mounting evidence from both our analysis and others (C.I.A., 1977; W.A.E.S., 1977) that the Business-as-Usual path leads to a world oil shortage, *perhaps just five years from now.* The implementation of a strong National Energy Plan, one that encourages both increased supply and intensified conservation efforts, should be this country's most pressing order of business.

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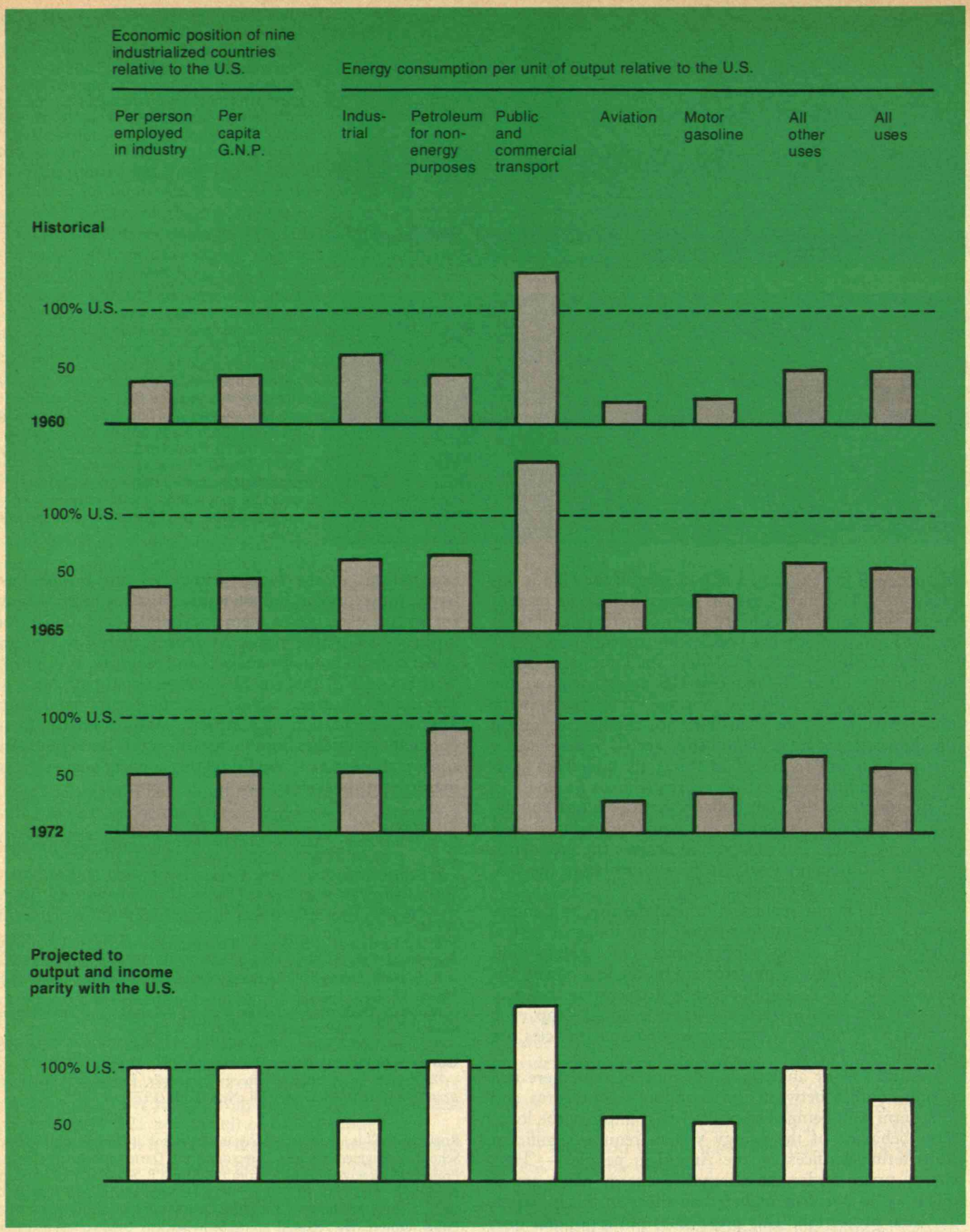

Direct comparisons of energy consumption between countries mask variations due to differences in productivity and incomes, climate, geography, types of fuels used and product mixes. To make this chart, the author attempted to anaylze and rationalize these characteristics to reveal real differences in energy use. It shows, for example, that in 1965 and 1972 nine other industrialized nations used per dollar's worth of G.N.P. 150 per cent as much energy as the U.S. for public and commercial ground transport and navigation, but only 31 (1965) to 34 (1972) per cent as much for automobile driving. The chart also shows that though foreign countries may have always used energy more frugally than the U.S., if their levels of productivity and income approach parity with those of the U.S. the differences in energy efficiency will largely erode.

Michael Boretsky
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A comparison of the U.S. with nine other industrial societies suggests that our energy conservation efforts should focus on industrial processing and automotive transportation.

Opportunities and Strategies for Energy Conservation

Energy conservation is a central thrust of President Carter's energy policies and it is clear that regardless of the outcome of the debates now in progress, conservation will be a national goal for the rest of the 20th century. Three unanswered questions arise as we plan for this effort: How much energy can be saved (conserved) without imparing the nation's productivity and/or levels of income? Can this conservation potential be realized by means of relative price increases — the sole policy tool employed by the Nixon and Ford administrations? And if price increases cannot effect the conservation we need, what kind of policies are in fact required?

Three approaches can be followed to determine the extent to which energy might be conserved in the United States:

— The econometric approach, analyzing the historic relationship between changes in energy prices and energy uses. Relying on this method, the Federal Energy Administration's Project Independence estimated that raising the price of energy from $3.67 per barrel of oil or equivalent (average for 1973) to $7 per barrel in 1973 dollars would reduce total energy consumption in the U.S. by about 15 per cent by 1985, reducing oil imports by about 50 per cent; and an $11-per-barrel price (1973 dollars) would reduce consumption by about 17 per cent, totally eliminating the need to import oil. The difficulty with this econometric approach is that the use of energy has changed over time not so much with changes in its prices as with changes in technology which have been totally or largely independent of price changes; consequently, there is no way to estimate the future effect of price on society's demand for energy with any degree of accuracy.

— A strictly technical approach, based on analysis of the efficiency with which energy is prevailingly used and judgments of how much the efficiency in each of these uses can be increased with current and readily available new technology. Using this approach, Marc H. Ross and Robert H. Williams (*see "The Potential for Fuel Conservation," February, pp. 49-57*) found that some 40 per cent of the energy used today could be saved without substantial changes in our lifestyle. The difficulty with this approach is that strictly technical judgments are being made about issues subject to socioeconomic preferences; what is rational in strictly technical terms may not be achievable in our socioeconomic environment.

— A comparative approach, in which U.S. conservation potential is inferred from data on uses of energy in foreign countries with environments similar to ours. Though this method is not necessarily based on maximum efficiency — foreign practices cannot be assumed to be 100 per cent efficient in a technical sense nor optimal in socioeconomic terms — it has one significant advantage: with appropriate methodology, international comparisons can yield fairly objective estimates of what may be really achievable. Unfortunately, the international comparative studies thus far made are essentially static (based on consumption comparisons in only one year), and they are otherwise not quite up to the methodological level required to produce truly instructive results.

The purpose of this paper, which is based on material initially prepared for the Secretary of Commerce in August, 1975, is to produce such results. Its goal is to answer three questions: What kind of energy-conservation potential do the foreign uses of energy suggest for the United States? Can this potential be achieved solely with appropriate price increases? And, if not, what other policies might have to be used to achieve the objective?

A Comparative Study of Energy Utilization

At any given time, international differences in the use of energy are determined by differences between nations' levels of production and/or income; differences in the structure of economic activity, particularly the proportion of energy-intensive products in the total output of goods and services (G.N.P.); in geography and climate; in the energy sources used; and — last but not least — in the relative efficiency with which energy is used. A reasonably correct assessment of how much energy the United States could save if it were to adopt foreign energy-saving practices requires an accurate determination of the extent to which U.S. energy use is greater than foreign on each of the foregoing accounts. Given such knowledge, the U.S. conservation potential — at least to the level of the most efficient other nation we can observe — would be a matter of definition. For purposes of this paper, we propose to define this potential as the excess use of energy in the U.S. (over that used by nine other industrialized countries) which cannot be explained by factors other than pure inefficiency; or alternatively, as that U.S. energy use which could be eliminated without any detriment to the economic activity, productivity, and/or substantive standard of living, according to standards of other industrialized countries.

The data on which the following analysis is based come from nine industrialized foreign countries: the United Kingdom, France, West Germany, Netherlands, Belgium-Luxembourg, Norway, Sweden, Italy, and Japan. The prevailing climate of these nine countries taken as a

whole seems to be fairly similar to that of the United States; therefore, no laborious adjustment on this account has been required in making the comparisons. The data on which all of these estimates are based come largely from publications of the United Nations and the Organization for Economic Cooperation and Development (O.E.C.D.) which, in turn, are based on official reports submitted to these organizations by member countries; the background and general information, however, are either from individual country publications or studies by other analysts. The principal time frame of the analysis, 1960 to 1972, was largely dictated by the availability of consistent data unaffected by the O.P.E.C. oil embargo and post-embargo developments.

From this data we drew and made estimates of the consumption of energy per person employed and per dollar's worth of G.N.P., or energy consumption per person employed and per dollar's worth of output in the case of industrial use, by type of primary source (coal, oil, natural gas, and hydropower) and for six major types of uses: industrial use for productive purposes; energy resources used for nonenergy purposes (petroleum used for lubricants and petrochemical feedstock); energy used for commercial ground transportation and navigation; use of energy for aviation; use of gasoline, largely for private automomobiles; and energy used for all other purposes, largely residential and commercial.

In the calculation of comparative energy consumption per unit of G.N.P. and of industrial output, the G.N.P. and industrial output of individual countries were valued in effective purchasing power equivalents rather than at official exchange rates.

For comparison with data for U.S. industrial energy consumption, the information from foreign countries must also be weighted to allow for differences in product mixes. For example, industrial production (except mining and utilities) represents a significantly greater share of total production in all of the nine foreign countries than in the United States. On the other hand, industry represents a much larger proportion of total national energy consumption in the U.S. than abroad. Together, these two observations imply that the energy intensity of products produced in the United States is much greater than in the nine foreign countries. Two possible reasons for this greater intensity can be postulated: a more energy intensive product mix in the U.S., and/or lower efficiency of energy use in this country. A recent O.E.C.D. study shows that U.S. energy consumption per ton of product in several energy-intensive industries (iron and steel, paper, cement, and petroleum refining) is appreciably higher than abroad. However, we also know that certain product lines, most notably defense hardware, as developed in the U.S. are more energy-intensive than abroad, and the proportion of such product lines is much higher in the U.S. than in other industrialized nations. On balance, therefore, we conclude that the thesis of lower overall efficiency of energy use in U.S. industry is more plausible than any thesis which rests on the unique energy-intensiveness of all U.S. products, and we assume that 10 per cent of industry's use of energy is due to our uniquely energy-intensive products.

The amounts of energy required by different countries for public, commercial, and private transportation depend upon geographical characteristics as well as the energy-efficiency of the vehicles used. Clearly, the U.S. has a larger geographic area per person of population than any of the nine nations which we choose to study; our calculations indicate that had the nine foreign countries to cover as large a geographic area per person as the U.S., other things being equal, their consumption of energy for transportation would be 20 to 25 per cent greater than it actually is.

If energy inputs are measured in B.t.u.s., we must take steps to recognize differences in the relative efficiency of various sources of energy and methods of conversion. The following coefficients were used: coal, 1.00; petroleum, 1.50; natural gas, 2.00; and hydro and nuclear power, 3.00. The following is an example of the reasoning: In the U.S. coal is now used prevailingly (over 75 per cent) for the generation of electricity. Between the mine entrance and the horsepower of work coal-embedded B.t.u.s produce for the end-user, a number of losses take place: some 2.75 per cent of the coal is lost at and between the mine and the electric power plants; of the 97.25 per cent of coal-imbedded B.t.u.s delivered to electric power plants, some 32.5 per cent (which is to say 31.6 per cent of the initial B.t.u.s mined) become electric power; of this 31.6 per cent of coal-imbedded B.t.u.s that become electric power, some 9 per cent is lost in transmission and distribution; and of the 28.8 per cent of coal-imbedded B.t.u.s which become electric power delivered to the end-users, some 30 per cent is lost because of the end-users' power factors. All things considered, therefore, only about 20 per cent of the B.t.u.s imbedded in coal are prevailingly used in work actually benefitting society. Similar computations indicate that in oil this percentage amounts to about 30, in natural gas about 40, and in hydro and nuclear power 60 to 65 (about three times as much as in coal). These coefficients are admittedly rather crude, but for the kind of international comparisons that are undertaken in this study they tend to produce vastly better results than when B.t.u.s are compared directly, irrespective of source, as has commonly been done in other analyses of this nature.

The chart on page 56 shows how the nine other industrial nations compared with the U.S. in economic position and energy consumption per dollar's worth of output (G.N.P. or industrial output) in 1960, 1965, and 1972 when the adjustments explained in the preceding paragraphs (except the impact of geography) have been completed. The chart also incorporates a regression procedure, to reveal what energy consumption would probably have been in these countries had their per capita G.N.P. and industrial output per person employed reached the actual U.S. levels of 1972. In view of the changing levels of these countries' consumption of energy per dollar's worth of G.N.P. vis-à-vis the U.S. from 1960 to 1972, the *rationale* of this regression needs no further explanation.

How Much Energy Can the U.S. Save?

The next stage in the analysis is to derive from these figures the differences between the U.S. gross energy consumption by type in 1972 and the amounts of energy which would probably have been used, on the average, by nine foreign industrialized countries had their per capita production matched that of the U.S. in 1972, with appropriate adjustments for differences in population density, industrial product mix, composition of energy sources, and, implicitly, in climate. The results of this analysis appear in the table on the opposite page, which is the central product of this study. As defined, the figures represent the

Energy use	Excess U.S. energy use as a per cent of total energy used in each sector	Excess U.S. energy use as a per cent of total energy used in the economy
Industrial, for productive purposes	40	13.4
Petroleum products used for non-energy purposes	(5)	(0.3)
Public and commercial ground transportation and navigation	(11)	(0.3)
Aviation	0	0
Motor gasoline (largely private automobile)	37	8.0
All other uses (largely residential and commercial)	0	0
All uses		**20.8**

Parentheses indicate the amount by which U.S. consumption is *below* the estimated level of foreign use.

Though in strictly technical terms, U.S. energy consumption might contain some wastefulness in practically every type of use, comprehensive comparisons with the nine other industrial countries adjusted for differences in productivity, incomes, climate, etc., show that in socio-economic terms the U.S. uses energy excessively only in two categories — industrial and motor vehicles. If the U.S. eliminated these two excesses, however, the savings would exceed 20 per cent of all energy used in the economy.

amount of U.S. gross energy consumption which could, in principle, be eliminated without any damage to either the productivity or the standard of living of the U.S.

As shown in the table, in the aggregate U.S. energy consumption is essentially comparable with the nine other industrial nations except for two categories — energy used in industry for productive purposes and motor gasoline. In these two categories the U.S. is far in excess of other nations. In the aggregate the conservation potential amounts to about 21 per cent of total U.S. energy used in the economy; in industrial production the conservation potential is about 40 per cent; and in motor gasoline 37 per cent.

It is important to understand the meaning of this analysis. It says, for example, that the U.S. does not have conservation potential in either aviation or in residential and commercial uses. This statement does not mean that there are no conservation potentials in these areas in the U.S. from a technical point of view; it only means that if the nine foreign countries were as affluent as the United States, their subjects would fly as much and use as much energy in their homes and commercial establishments as the typical American.

It may also be important to note that our comparisons are all with the average of the nine countries, rather than with the most frugal foreign countries with respect to energy use. The probability that even the most frugal nations — France and Japan — do not use energy with 100 per cent efficiency strongly suggests that our 21 per cent conservation potential for the U.S. may be a conservative figure, an absolute minimum. Indeed, had we based our analysis on France's energy-use practices rather than the average for the nine foreign countries, we would have found a U.S. conservation potential of about 37 per cent, almost as great as Ross and Williams estimated on the basis of strictly technical considerations; and had we generalized from Japan's experience the suggested conservation-potential would have been about 30 per cent.

The question is whether this potential, or any of it, can be achieved. And if so, how?

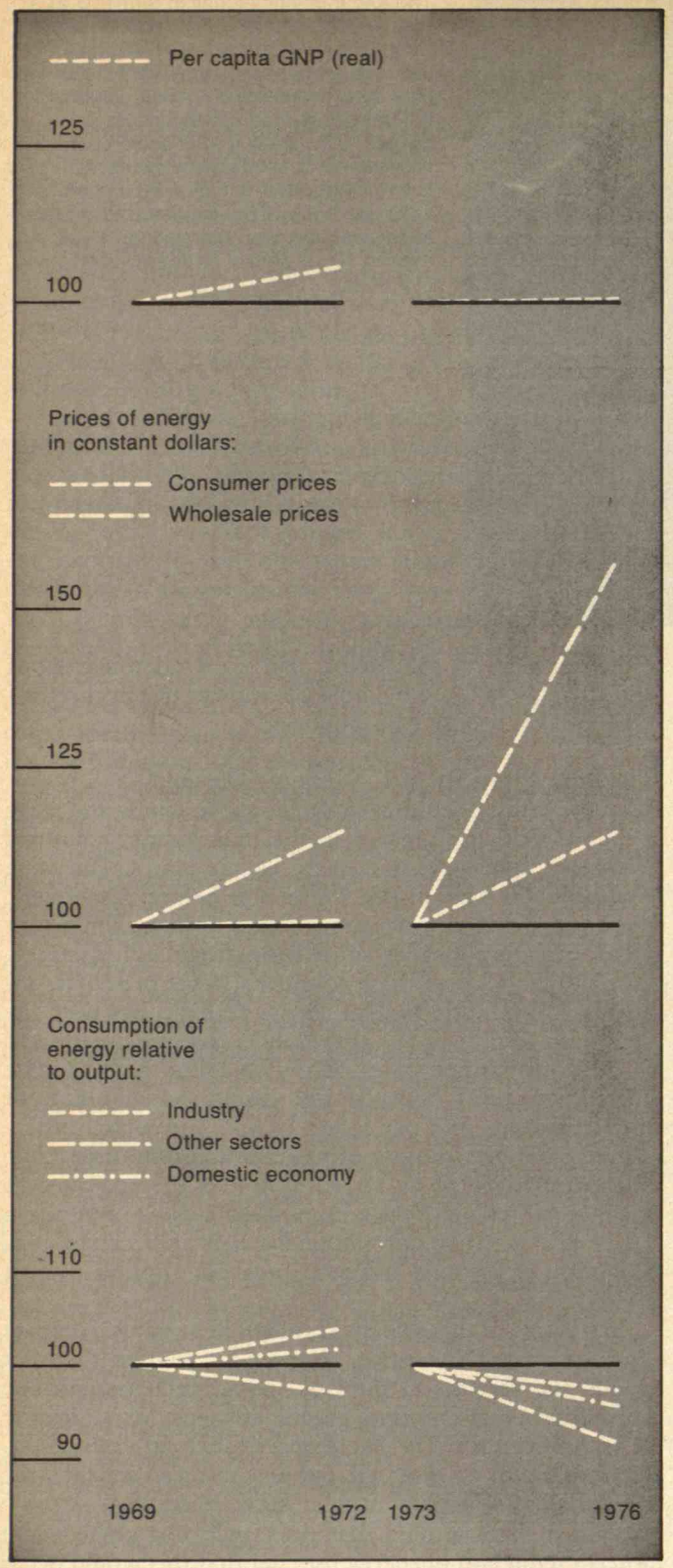
What can we learn and infer from this analysis about the effect on consumption of relative price increases, the tool proposed by the Nixon and Ford administrations and strongly favored by most economists to effect reductions in U.S. energy consumption?

The Price Elasticity of U.S. Energy Demand

We have established that throughout the 1960s and early 1970s the price of energy in the nine foreign countries was more than twice that in the United States. The same was probably true in the 1950s and before. Obviously, these much higher prices must have been an important factor in these countries' much more frugal use of energy, especially in view of these countries' lower per capita incomes. Indeed, our analysis shows that this has been the case with respect to the automobile, the principal factor in the consumption of gasoline. We found high *positive* correlation (.88) between per capita consumption of motor gasoline and per capita G.N.P. and high *negative* correlations between per capita consumption of gasoline and price levels of motor gasoline (−.76), and average mileage per gallon of the automobiles in use (−.98), and a fairly low negative correlation between per capita consumption of gasoline and per capita use of public transit (−.45).

In the face of this evidence it might be sensible to expect that increasing the price of gasoline relative to other goods and services in the U.S. should decrease gasoline consumption and produce greater efficiency of energy use in transportation. The likelihood of such an eventual effect can hardly be doubted, but we must also consider the questions of when and at what price to society.

Our analysis implies that price increases alone might force a reduction in energy use, but that this would occur only if the price increases were really dramatic — in which case they might and probably would represent an unacceptable tradeoff to society in terms of inflation, unemployment, and decreased productivity. This conclusion is supported by the following data: in three years from 1969 to 1972, the overall price of energy in the U.S. in real (1969) dollars increased by about 10 per cent, real per capita G.N.P. (income) increased by 5.3 per cent, and the consumption of energy per unit of domestic output rose 1.9 per cent. But in the three-year period from 1973 to 1976, while per capita G.N.P. remained practically



Between 1969 and 1972 U.S. per capita G.N.P. increased by 5.3 per cent, the overall price of energy (weighted average of wholesale and consumer prices) increased about 10 per cent, and total energy consumption per unit of G.N.P. increased by 1.9 per cent. From 1973 to 1976, however, when per capita G.N.P. remained practically constant, the overall price of energy rose by about 44 per cent but energy consumption per unit of G.N.P. fell only slightly.

static, the price of energy in real dollars rose 44 per cent and energy use per unit of domestic output declined only 4.1 per cent.

Other things (particularly per capita income) being equal, changes in consumption relative to changes in prices yield what economists call an elasticity of demand with respect to price. In the field of energy, we should note, wholesale prices are generally applicable for industry purchases, consumer prices for consumer purchases, and a (weighted) combination of the two for all purchases. Because of the aforementioned 5.3 per cent growth in per capita G.N.P. (income) in 1969-72, not all elasticities for this period can be estimated with precision, except for industry's demand (where change in per capita income is generally unimportant) and where the elasticity seems to have amounted to only −.15. But for 1973-76 when G.N.P. remained practically constant and when the issue of energy conservation became for the first time important, the estimates of price-demand elasticities for all sectors are rather straightforward:

— Elasticity of industry's demand = −.14 (practically identical to that of 1969-72)
— Elasticity of other sectors' demand = −.070
— Elasticity of all sectors' demand = −.10

By all economists' standards, these energy demands would be considered extremely *inelastic*. Moreover, at least three facts suggest that these estimates may in fact be much too high:

— In 1976 the aggregate level of industrial activity was 3.8 per cent below that of 1973, and this average shortfall was most probably due to much greater shortfalls in some of the most energy-intensive industries; for examples, the real value of construction was down by 19.2 per cent, the real value of primary metals output was down by 15 per cent, and the real value of paper products was down by at least 6 per cent. This implies that a substantial proportion of the apparent decline in industry's use of energy between 1973 and 1976 is attributable to a disproportionate reduction of energy use in the most energy-intensive industries, due not to changes in the price of energy but to reduced demand for products. Without this selectively reduced economic activity, the apparent elasticity would undoubtedly be much smaller.

— Between 1973 and 1976 the U.S. average unemployment rate jumped from 4.9 to 7.7 per cent of the labor force, thus making noncommuters out of almost 3 million people. These noncommuters required proportionately less energy than would be suggested by data on decreasing G.N.P. or income because they received unemployment and other transfer payments but did not require comparable energy expenditures.

— Finally, the energy consumption figures used in these computations are given in B.t.u.s unadjusted for changes in the composition of the fuel mix. The adjustment would make apparent elasticities smaller than shown.

All of these considerations imply that the true elasticity of demand for energy with respect to price in this three-year period — particularly that of industry — could have been as small as −.05. For the longer run, it is undoubtedly higher (but probably not much higher) than −.10, that is, about twice that of 1973-76. If that is the case, it means that energy price increases of 800 per cent above the prices of all other goods and services would be required to quickly reduce industry's energy demand by as much as 40 per cent, the estimated conservation potential. Similar price increases would also have to be

promulgated for motor gasoline to achieve similar conservation goals in this case.

Needless to say, such huge price increases are unthinkable over a short period of time, and if they were promulgated the increases would probably result in economic disaster rather than conservation.

The Constraints of Technology and Economics

As we see it, there are extremely important technological and economic difficulties in achieving substantial energy conservation by mere increases in the price of energy.

As we pointed out earlier, the largest potential for U.S. energy conservation is in industry. But U.S. industrial methods and characteristics do not change rapidly; if U.S. industry is now spendthrift in its use of energy compared with foreign industry, this must have been true for at least 30 years and probably much longer. The use of energy is "institutional" in nature — built into people's habits and, most importantly, fixed by the capital equipment and technology on which industrial operations are based. Institutional change is by nature slow, and it will take quite some time to eliminate industrial inefficiencies. Indeed, even if the needed know-how were readily available, it is simply impossible to replace overnight hundreds of billion of dollars worth of capital equipment which determines the efficiency or inefficiency with which energy is used in the economy.

An equally skeptical view is suggested by the fact that energy still represents no more than about 10 per cent of the total value of industrial output. If the price of energy went up by 50 per cent, for example, while all other prices remained unchanged, the cost of energy would increase to 15 per cent of the value of output. In the period from 1965 to 1972 each percentage increase in industry's use of energy per person employed generated an increase in total output of 0.6 per cent. Assuming that this relationship continues to prevail, the two percentages would work against energy conservation. For example, a company which succeeded in curtailing its energy use by 10 per cent would find the cost of its products reduced by only 1.5 per cent, but it would have foregone the opportunity to increase its output per person employed, and perhaps its profits, at least temporarily, by 6.0 per cent. Needless to say, no rational decisionmaker would opt for this choice.

As a matter of realism, we should expect, therefore, that industry's response to an across-the-board increase in the price of energy would probably be:

— Companies ready or nearly ready to introduce energy-saving technological innovations would speed up these introductions and curtail energy use by as much as this new technology would permit. Production and productivity would not be affected. Inasmuch as energy saving as such has not been a significant factor in industry's past technological progress and new technology usually has a long gestation period, it is unrealistic to expect that there are many companies that can do this. Moreover, most of the readily available new technology has probably already been put into use in response to the price increases that have already taken place.

— Most companies which lack energy-saving technology and the know-how to develop it but which have secure competitive positions in the market would simply continue to buy the energy they require at higher prices and pass the cost increase on to their consumers. The result would be a substantial increase in inflation but no change in the volume of production, employment, energy consumption, and productivity. The extremely low elasticity of industrial demand for energy in both 1969-72 and 1973-76 suggests that the bulk of the companies in U.S. industry might be in this category; and

— Companies which lack new energy-saving technology and the potential to develop it and which are not able to pass cost increases to their consumers because of competitive constraints will sooner or later curtail their use of energy at the expense of reduced production, productivity, and income. To the extent that many companies find themselves in this predicament, unemployment and decreased industrial prosperity could be a serious national problem. This would be especially serious should foreign industries not be subject to the higher energy prices imposed in the U.S.

In summary, then, we conclude that because of technological and microeconomic constraints, attempts to force industrial conservation by means of further price increases might result in little energy savings while risking increased inflation, decreased productivity and international competitiveness, and perhaps decreases in our standard of living.

The Constraints of Capital and Lifestyle

In the case of the other large conservation potential — private automobile driving — there are four reasons for greater use of gasoline in the U.S. than in the nine foreign countries we have studied:

— The lower density of population in the U.S. Our larger geographic area per head of population requiring longer distances to travel;

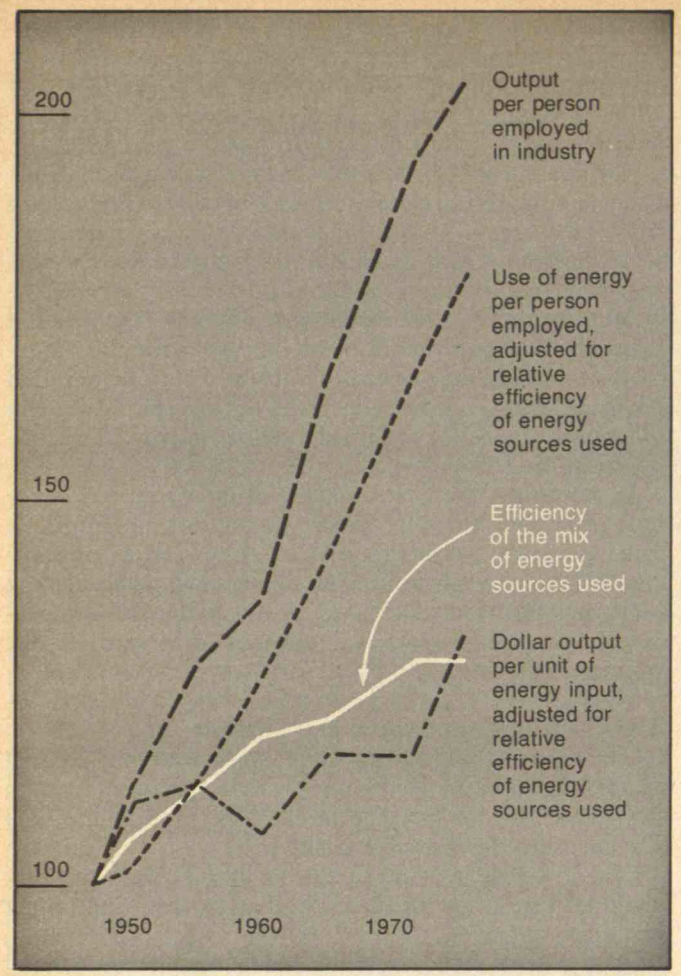
— The lack of well developed public and/or commercial transit alternatives to the private automobile. Public and/or commercial transit systems of other countries are four to five times as large as ours;

— The fact that automobile ownership has become an important feature of our culture. Automobiles are in fact status symbols and keys to recreational as well as vocational opportunity.

— The facts that U.S.-built automobiles are on average less efficient, by one-third to one-half, than foreign-made automobiles, and that we operate over 120 million of them, more on a per capita basis than the nine foreign countries.

The price of gasoline has no effect on the longer distances over which Americans must travel. But increases in gasoline prices could affect our willingness to expand transit systems and improve the efficiency of our automobiles, *sine-qua-nons* for reducing gasoline consumption. Achieving the 37 per cent saving of energy used in automobile driving, equivalent to 8 per cent of all energy used in the economy, will require a four- to five-fold expansion of transit systems and a complete replacement of the present stock of automobiles with a new stock which is 50 to 100 per cent more efficient. Even given very strong determination on the part of every American, neither of these can be achieved in less than 10 to 12 years. In the meantime, most of the conservation that would be achieved by large gasoline price increases would be on account of curtailed pleasure and other "optional" driving foregone, which cannot be large because this type of driving represents a small proportion of the total, and by those forced off the road because of their inability to pay.

Across-the-board price increases would also have the



Though the growth in U.S. productivity has been essentially parallel with our growing use of energy, industrial use of energy per person employed in industry increased from 1947 to 1976 about 13 per cent less than the real output per person employed, which means that we have been using energy with progressively, albeit slowly, increasing efficiency.

The chart, with data indexed to 1947, suggests that any future shift to coal and coal-based electricity, replacing more efficient natural gas and oil, would jeopardize our rate of productivity growth unless the relative inefficiency of coal is offset by accelerated technological progress in energy saving. The data also suggest that, because of the close historical relationship between energy use and productivity, *arbitrary* attempts to reduce the economy's energy consumption might easily jeopardize our standard of living.

disadvantage of affecting all energy uses equally — including those in which there is no or little technical or socio-economic potential for conservation. Thus the cost of petrochemicals, public and commercial transportation, and residential heat and light would rise along with cost of energy for industry and gasoline for automobiles, yielding some conservation but also, and primarily (because of extremely low elasticity), inflation, loss of jobs, and other hardships.

The Need for Selective Mechanisms

History suggests that the price mechanism is generally an excellent tool for solving short-term and rather specific distributive problems. It may also serve well in solving medium- and even long-term problems if those problems are narrow, affecting one product or perhaps one industry. But the price mechanism is incapable of discriminating between "good" and "bad." For solving a problem as complex, varied (full of "good" things as well as "bad"), and as long-term as our energy problem, the price mechanism does not offer a viable solution. For such problems, pragmatic people (and we claim to be a nation of pragmatists) have always relied on direct approaches to eliminate the "bad" and leave the "good" unharmed.

Energy prices have increased some 14 to 57 per cent more than all other prices since the embargo; these increases should have been more than sufficient to induce all users of energy to economize as much as their economic realities would permit, and to induce producers to drastically speed up the development of new domestic energy sources. If demand is in fact as inelastic as this analysis indicates, further across-the-board price increases by deliberate policy action would be uneconomic and harmful to the stability of the economy, and might eventually prove to be destructive to the socio-economic system which we have enjoyed for so long.

Policies that would attack the inefficient and, therefore, "bad" uses of energy directly and leave the "good" uses alone, and thus force energy conservation in a rational way, might prove to be administratively difficult and politically unpopular, but there is no *a priori* reason why such policies cannot be instituted and even fewer obvious reasons why this should not be done, if it is clearly in national interest.

Michael Boretsky's specialty is the economics of new technology. He was educated at the Polytechnical Institute of Lvov (Ukraine), the University of Erlangen (Germany), and Columbia University (Ph.D. 1964) and held positions at the University of North Carolina and the U.S. Bureau of Labor Statistics before joining the Department of Commerce in 1962. Though this article is based on a major study prepared by Dr. Boretsky for the Secretary of Commerce in August, 1975, the views expressed in it do not necessarily represent those of the Department or of any other agency of the U.S. government. Dr. Boretsky acknowledges the assistance in the study of Robert G. McKibben.

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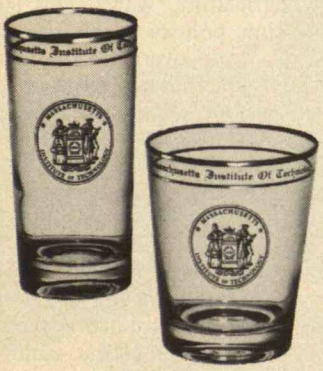

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Trend of Affairs

Trends This Month

ENVIRONMENT

Montology: The Ecology of Mountains

Mountains. They've been climbed, farmed, and worshipped, photographed, and mined. Lately we're finding they've been exploited and overused. Far from eternal, mountains with their thin air and soil are delicate, and their disruption can have far-reaching effects.

The ecological assaults on mountains are far more serious than the cries of dismay voiced by hikers finding beer cans on trails imply.

For example, in the last 30 years at least 50 per cent of the forests on the Himalayan slopes and foothills of Nepal have been stripped away. As a result, the thin soil of the slopes is washed toward the plains under the force of the monsoon rains, silting the rivers and filling the Ganges, whose sources lie in the Himalayas. The floods of Bangladesh and the water-borne diseases of poorly drained Calcutta are both indirect results.

Halting the destruction of the forests is no easy task. Agriculture in Nepal is based on wood, just as U.S. agriculture is based on petroleum.

The Nepalese are experiencing their own energy crisis. The forests are cut to fuel the cookfires of individual homes, and for heat and light. The people are poor, making only $100 to $200 each year, and can afford no other energy source; government intervention, by legislation or economic incentives, is impossible.

The population is growing at a rate exceeding 2 per cent per year, so the woods are stripped even more quickly as time passes. The farmers are forced to build increasingly precarious terraces ever higher on the hills to grow grain, and erosion follows in their wake. Their fertilizer is manure, which the farmers gather with extraordinary enthusiasm. But as population and farming areas expand, so do the numbers of animals, putting additional pressure on the high grassy slopes.

The Nepalese government is aware of the problem, and has initiated family planning programs. But information and technology travel slowly in roadless Nepal, and the independent mountain people are slow to accept new ways. Hill planners have been advised to transfer some people to the low plains in the terai region on Nepal's southern border, but this is a poor interim solution, at best promising only an additional 15 years to solve the population problem in the hills.

The King of Nepal, in an interview published in the *Far Eastern Economic Review*, said that "the imbalance between the hilly region and the plains and the resultant pressure on the plains due to migration from the hills; lower rate of growth of economy than population; and lack of knowledge of our own country and the building of capability to tackle our problems" are the three facts from which many of Nepal's problems stem.

Politics plays its part as well. In the early 1950s the forests of Nepal were nationalized, removing feudal control and leading to today's "tragedy of the commons" situation. At the same time the Tibetan border to the north was closed, bringing many Tibetan refugees to Nepal and forcing some mountain people to turn to tourism, rather than trade, for their living. Tourists in greater numbers fill the government's coffers, but weaken the culture of the high mountain people they come in contact with. And more forests are cut to provide trekkers with campfires.

Energy, agriculture, water- and land-use, population, politics — the issues are the same the world over. But the mountains are so fragile that any upset of their delicate balance has more immediate consequence.

As recently as 15 years ago, people seeking to maintain ecological balance had no conceptual framework to direct their efforts. Now environmental science has emerged with its corps of scientists and planners striving to limit our desecration of nature. Mountains, studied as discrete systems, can benefit from the same approach. As oceans have oceanography, mountains need a field of study uniquely theirs.

Terraces rise in the Himalayan foothills of Nepal. As the population grows, farmers build new terraces in order to farm more land. As the steepness of the crop area increases, so does the potential for erosion. (Photo: Ron Halliwell)

Thirty-four people — government officials, planners, agriculturists, and academics — gathered in Cambridge early in May under the auspices of the Institute on Man and Science to acknowledge the necessity of mountain study. They coined the word "montology" to describe the new science. As one participant pointed out, "montography" would indicate writing about and mapping the mountains; the group chose a more active name.

The conferees were reluctant to immerse this emerging field in bureaucracy at its very inception. But Klaus Lampe of Germany pointed out that an international institute for mountain studies would serve useful functions. As an information center, the institute would collect and distribute data that have already been collected on mountain ecology, thus giving researchers a statistical base and dissuading those who might replicate already completed studies. The institute would be a financial necessity, distributing grants and channelling money from other institutions. For teaching the public, the institution would be invaluable; mountains as yet have no Jacques Cousteau to plead their cause, and public awareness of the plight of mountains is low.

But as an agency whose goal is action, the institution would face difficulties similar to those of already established agencies.

Mountain inhabitants, from the Himalayas to the Appalachias, share the same independence and resistance to outwardly induced change. Jane Alexander, the State of Pennsylvania's Deputy Secretary of Agriculture, gave one example from her home state. Strip mining and overpopulation (in the form of commercial development of "summer homes") have denuded much of the Appalachian forests, and resulted in destructive spring floods in the basins of the rivers flowing from the mountains. The state legislators, reluctant to disturb their mountain constituency, have been unable to resolve the conflicts between the economic and environmental health of the area. The only jobs available in the area are in the mining and tourist industries; to deny these is to sentence the mountain people to unemployment or force them to leave the area. Only one law has been passed in the state in response to erosion-induced flooding, she said. It has been mandated by the state that dwellers on the flood plain must buy flood insurance. Meanwhile, tree clearing continues.

The bridge between knowledge and action is difficult to cross, regardless of the situation or the education of the people affected. The conference did produce some good suggestions, however, which could be implemented by "montologists."

John Neiderhauser, of the Potato Institute in Lima, Peru, has spent many years studying the agriculture of Nepal and Peru. He suggested that some very small changes might yield amazing results. When Sherpas plant potatoes, for example, they first spread the entire field evenly in manure. The potatoes are planted in small holes, and benefit only from about 2 per cent of the fertilizer. It shouldn't be too hard, he mused, to suggest that the manure be placed around each plant, only where it is needed. "There are many such packages we could deliver," he said.

Tourists could be charged for the external economic costs of their travels. A load of wood, it was pointed out, costs about 50 rupees ($4.00) to the trekkers to which it is delivered. This pays for the labor of the porter who gathers and carries the wood, but leaves the replacement to nature. Perhaps a replacement tax could be levied on trekkers. Externalities are the heart of the resource allocation costs, added Jean Krause of First Boston Corp. But it might cause tourism to decline.

Face-to-face interaction with mountain dwellers will be required if methods for tapping water for power, new plants and seeds, family planning methods, or any such "package" is to be delivered effectively. Donald Eberly of ACTION suggested the formation of volunteer groups similar to the Civilian Conservation Corps of the 1930s. These would not be limited by age, and unlike the Peace Corps could be manned by citizens of the affected country. Outsiders, it was generally acknowledged, are singularly unsuccessful in inducing change.

The conference followed up a five-day symposium held in Munich in 1975 on the same topic. Immediate action was petitioned at that time; until now action has consisted of another conference. The Cambridge conference issued another call for action, which they called the "Cambridge Manifesto" (*see below*). — *S.J.N.*

Cambridge Manifesto

The Cambridge Conference on Mountain Environments issued the following declaration of needs and intentions:

A clear and present danger threatens the integrity and viability of the mountain regions of our planet. The accelerated destruction of mountainside forest cover and accompanying soil erosion has seriously damaged the survival opportunities of the plants, animals, and the human communities who depend on them. In the Himalayas, in the Andes, in the East African Highlands, in the Rockies, and elsewhere, vast upland areas are on the verge of becoming deserts. A consequence has been the silting of rivers and harbors, the aggravation of flood conditions in the valleys and plains on which nearly half the earth's peoples depend for food and water.

We who attended the Cambridge Conference on Mountain Environments fully endorse the analysis made by the experts from the mountain regions of the whole world who assembled at Munich in 1975. We call upon international and national leaders and upon all citizens concerned with the future of humanity to cooperate.

The first step must be initiating a network of activities, projects and institutions with the object of halting the destruction of mountain environments and promoting conservation-oriented development. The national governments principally concerned must create schools, research institutes and legislation, and must sponsor cadres of volunteers to reclaim the destroyed land and protect and improve the fragile topsoil of endangered land.

The world academic and research community must make its best advice available immediately. We urge governments, universities, research institutions, and international agencies to summon the resources for an interdisciplinary, interprofessional and all inclusive effort to preserve and extend the mountain resource base, without which development efforts in half the world will be frustrated and abridged. The governments of countries in mountain regions will be justified in an insistence on a coordinated approach to replace the present competitive programs of "foreign aid." We envision a comprehensive approach, taking into account the underlying dynamics of agriculture, energy practices and alternatives, tourism and demography, and all other factors which affect the mountain context and the destiny of the dependent populations.

This Conference recommends the prompt establishment of specialized journals, research and teaching institutions, volunteer mountain improvement corps, and model mountain reforestation and forest development schemes as a practical first step in realizing our goal. The governments of nations in mountainous regions have every incentive to meet and draw up mutually useful compacts for the conservation-oriented development of hydro-electric and other joint resources on a basis of the interests of watersheds and their populations. Let development in a framework of responsible science generate the resources for mountain protection and thus, with forethought for the future, contribute to the wise management and husbanding of a resource base mankind has neglected to its loss and peril.

Not Only How the Robin Died, But Why

For 20 years bioscientists proclaimed the environmental hazards of countless exotic materials and of unrestrained growth. Then *Silent Spring* and later *Limits to Growth* became best sellers, environmental issues — real or imagined — began to have a place in debates on science and public policy, writing environmental impact statements became a specialized national industry, and the quality of at least some of our air and water began to rise.

But the job of achieving a better balance between exploitation and conservation has barely begun, and suddenly the monkey is back on the scientists' backs. Now that we are ready to make more sophisticated decisions, the science of ecosystems is inadequate in both scope and depth, by definition everywhere and by circumstance nowhere.

Richard Carpenter, Executive Director of the National Research Council's Committee on Natural Resources, argues for more fundamental environmental science: too many questions about ecosystems remain unanswerable. Professor Lynton K. Caldwell of the University of Indiana agrees, and he further argues that scientists must take a new, broad view of their task when they confront environmental problems. Both spoke at sessions of the American Association for the Advancement of Science in Denver early this year.

Baselines vs. Emotionalism

Here are some of Dr. Carpenter's frustrations with the state of environmental science:

— There is too little baseline information, no way to estimate the natural characteristics and behavior of many systems. Without that kind of information, there is no good way to set goals and make the cost/benefit analyses on which environmental decisions should be based.

— We often know too little about a natural ecosystem to predict the effects of an intervention we propose. And even when we understand one system adequately, we lack knowledge to extrapolate that understanding to apparently similar systems in other environments.

— We lack good environmental monitoring. Missing records from the past cannot be constructed now, but today's monitoring programs often turn out to be ill-founded, inconsistent, and short-lived.

— Perhaps because we lack systemic data, we too often evaluate an ecosystem on the basis of only a single element within it. As a special example Dr. Carpenter cited the emotionalism surrounding the concept of endangered species; we may soon need an "endangered projects act" to complement the endangered species act, he said.

— Environmental impact statements have been a procedural success — they've raised everyone's consciousness of environmental issues and have made possible public participation in decisionmaking. And the best of them, based on good research, represent serious attempts at modeling and prediction. But too often environmental impact statements are imprecise and incomplete — an "unreviewed, gray literature useless as scientific data." And in no case is there systematic retrospective evaluation, which means there is essentially no scientific return on the investment they represent.

Small Horizons, Traditional Concerns

Dr. Carpenter and Professor Caldwell agree that ecology is a "difficult science" because it involves complex interrelationships of systems, each of which is itself complex. But the problem is unnecessarily complicated by both administrative and conceptual constraints.

The responsibility for environmental science at the federal level is fragmented and ill-defined: the Environmental Protection Agency has regulatory but no research responsibility; the Department of the Interior is illogically supposed to at once exploit and protect resources — a "hostile environment" for the basic research we need, says Dr. Carpenter. There is no point of leadership.

Scientists themselves add to the problem, too, says Professor Caldwell: their horizons are too small, their concerns too traditional.

Consider the death of a robin by an unknown chemical. The scientist must, of course, establish the cause and mechanism of death. But he or she should also consider the social conditions which brought forth the dangerous chemical, and should look for technical and societal solutions which will render such an environmental insult impossible in the future.

"The changes most needed," Professor Caldwell told the A.A.A.S., "are those that would enable scientists and policymakers to identify whole problems, taking account of all critical parameters and assessing the consequences of all practicable solutions." — *J.M.*

ENERGY

All Together Now for Conservation

Our record has been "abysmal," but suddenly the priorities of the White House and Capitol Hill are coming together. Ronald Craven, of the Washington law firm of Miller and Chevalier, says effective energy conservation is no longer a possibility; it's a certainty.

"I'm not exaggerating," he told the American Association for the Advancement of Science this winter. "The mood of Capitol Hill is not that conservation is an option but a necessity."

How will it be done? Here are some suggestions Mr. Craven hears as he perambulates in the Washington scene:

— Greater emphasis on converting industries and utilities from natural gas to coal. A modest program was mandated by Congress in 1973, but very few U.S. utilities have as yet switched from oil to coal, and too few have made preparations to do so.

— A special, hard look at the transportation sector. Among the suggestions are regulatory changes to increase efficiency, more investment in rail transport, and more stringent limits on the gasoline consumption of automobiles than those legislated in 1975.

— Tax incentives, including tax write-offs for the cost of energy-conserving retrofits in homes, apartments and perhaps even industry. Mr. Craven admits that he is a "tax purist"; in an ideal world, taxes should not be used to achieve social policy. But the tax incentive is the only one he can find to encourage apartment owners to make energy-saving improvements.

— A substantial gasoline tax — perhaps $1.00 per gallon. This will cause inequities, Mr. Craven admits, but some of those can be mitigated by refunds to drivers of efficient cars. People who drive inefficient automobiles are imposing a burden on the country which they don't now repay, says Mr. Craven. "The time has come to take some significant action," he told the A.A.A.S. Both Congress and the White House know that "we're not going to deal with this problem by a popularity contest." — *J.M.*

Physicists Evaluate Nuclear Fuel Cycle

A calm, rational voice has recently been added to the debate over nuclear waste disposal, with the release of an American Physical Society sponsored study of the nuclear fuel cycle. The independent study, released last spring at the American Physical Society meeting in Washington, D.C., concluded that today's technology or logical extensions of it will allow "safe and reliable management of nuclear wastes and control of radioactive effluents." Thus, the study participants saw no need for the moratorium on reactor construction advocated by many nuclear critics.

The study was significant because it represented the assessment of physicists with little previous involvement in the nuclear debate and with no apparent commitment to either side of the various issues. After a year of study of the various issues, the "Study Group on Nuclear Fuel Cycles and Waste Management" urged:

—Immediate completion of federal regulations governing the forms that nuclear wastes can take, and how they should be transported, stored and isolated.

—Two demonstration facilities for the

storage of high-level wastes in stable geologic formations. The group confirmed E.R.D.A.'s belief in salt beds as appropriate repositories, but also urged a second demonstration facility in granite or shale formations. However, they were concerned that insufficient attention would be given to making stored spent fuel fully retrievable, should reprocessing be delayed. Technologies for such a stowaway cycle need full-scale demonstration.

—Further industrial-scale reprocessing facilities to gain experience. The group, however, saw no real urgency to begin reprocessing, for there appears to be enough uranium to fuel current light-water reactors for many decades.

—Investigation of "safe" fuel reprocessing schemes which discourage theft and conversion of nuclear materials into weapons. Such cycles avoid the transport of pure plutonium by maintaining it always in combination with uranium which would make weapons conversion difficult and increase the volume of material that would have to be stolen to make a bomb. The study participants also saw safeguard value in restricting plutonium-burning reactors, reprocessing and enrichment facilities to "internationally controlled" sites in a country. "Denatured" fuel cycles involving uranium and thorium would be allowed at nationally controlled sites. Thus, fuel under national control would contain only diluted plutonium, which would be much more difficult to convert to weapons use.

—More evaluation of heavy-water and light-water reactors that would use fuel more efficiently. The group found, however, that the fast breeder reactor was still the most resource efficient system, although they did not examine controversies over the safety of the proposed liquid metal fast breeder reactor. — *D.M.*

Shaving the Power Peak

Electric power companies are only too conscious of the daily and weekly schedules of their customers. When the days are hot and air conditioners are humming, or when weekday activity is at its height, the utilities struggle to generate enough power to keep up with demand. When customers are nestled snug in their beds, or enjoying a Sunday's rest, expensive generating equipment sits idle.

Thus, utilities are eager for new methods to store power generated during slack periods to ease the strain of heavy-demand periods. The Electric Power Research Institute and the Energy Research and Development Administration recently have assessed the technologies of energy storage, and predict success for several of them. According to the recently released study, "An Assessment of Energy Storage Systems for Use by Utilities," storage systems could supply the equivalent of about 5 per cent of U.S. electric energy requirements, and could shave up to 17 per cent off the peak-load requirements of U.S. utilities. The economic benefits could be considerable, for peak-load power demands are usually satisfied by gas turbine generators, powered by expensive oil and gas. If utilities possessed storage capabilities, steadily running nuclear and coal plants could store energy at slow periods to supply peak power.

Hydro-pumped storage is the only storage method now in use commercially. In hydro-pumped systems, off-peak power is used to pump water uphill into a reservoir, and peak power is generated by running the water through a turbine.

For the short term, the study identified several other economically promising storage methods. It could be practical to pump air from a combustion turbine into underground caverns, aquifers, or salt cavities, with the compressed air spewed back through a combustion turbine to meet peak needs. Even more economical would be storage of energy by heating huge tanks of water or oil, and recovering the heat to generate electricity during peak power demand. Direct storage of steam would not be so economical, said the study, because of the high costs of pressure vessels to retain the steam.

Even though the lead-acid battery has been around since 1880, it still has not been adapted for utility peak storage, and probably never will be, the study pointed out. The high costs and short useful lives of such systems make it impractical. This is not to say that batteries will not some day relieve peak power demands. The study concluded that advanced batteries, with higher storage capacities and longer lifetimes could become feasible in the 1980s. Many have proposed that energy could be stored in the form of hydrogen, but the E.P.R.I.-E.R.D.A. study concluded that the efficiency of conversion of electricity to hydrogen was so low — about 50 per cent —that this method will not be economically feasible except for specialized applications where a high storage capacity was needed, and efficiency mattered little.

Besides the lead-acid battery, the study rejected only one other storage technology as being totally out of the question economically — flywheel storage. A flywheel system, which would be spun up to high speeds on off-peak power and tapped for peak power needs, would be extremely expensive, the study concluded, and there is little chance for reducing its costs.

The E.P.R.I.-E.R.D.A. researchers cautioned that the future could hold even greater surprises for energy storage technologists. Research on superconducting magnetic energy storage, for instance, is still in its infancy, and could offer even greater promise to relieve utilities of keeping up with the ups and downs of their customers' lives. — *D.M.*

The Stay-at-home Nuclear Accident

The supposedly impossible happens: your local nuclear power plant experiences a catastrophic accident, releasing a radioactive cloud, which drifts toward your community. The utilities have prepared for this unlikely event by mapping out evacuation plans, and, in fact, nuclear plants are sited in low-population areas, where evacuation would be relatively easy.

But it may be wiser to stay put in your house, seal the doors and windows, breathe through a handkerchief, and wait till the cloud blows over, according to recent findings of a group of University of Pittsburgh scientists. In a paper delivered at the American Physical Society last spring, the scientists — J. E. Alzona, B. L. Cohen, H. N. Jow and J. O. Frohliger — revealed that staying indoors could reduce the radiation dose due to inhaled radioactive particles from one-third to one-tenth of the outdoors dose. Since inhaled radiation accounts for about 70 per cent of the radiation exposure in such a nuclear accident, staying indoors could afford considerable protection.

The scientists base their findings on experiments that measured indoor and outdoor levels of lead, bromine, iron and zinc particulates in air in the city of Pittsburgh. The lead and bromine particles come from vehicular traffic, while the iron and zinc originate from local industrial emissions. The scientists first cleaned the air in a selected room with an electrostatic-precipitator-type air cleaner, and then allowed the level to stabilize with respect to the outdoor air, with door and windows tightly shut and sealed. Air particulate samples of both indoor and outdoor air were then taken and compared. The indoor-outdoor ratio of particles typically stabilized at one-fifth for iron, two-fifths for zinc and lead, and one-third for bromine, the researchers found.

"Thus, it is reasonable to say that the estimated population inhalation dose in case of an accident can be reduced by a factor of two to three if the people warned of an approaching radiation cloud follow instructions to stay indoors, close all windows and seal all cracks visible to the outside," said the scientists. "The protection afforded by a closed, parked car seems to be even greater by a further factor of three, though why this should be so is not immediately clear." The scientists also noted that a handkerchief over the mouth and nose reduced inhaled dosage even further.

"Since remaining indoors and sealing the cracks around windows significantly reduces the radiation dose, large-scale evacuation (which will always involve some casualties) may be unnecessary and even counter-productive," they concluded. — *D.M.*

Of Quarks, Reporters, and Scientists

That final phantom particle, the quark, which physicists postulate as the basic unit of all matter, has proven totally elusive. So much so that scientists have now invented theories to explain why a quark has never been blown apart from its fellows inside high-energy particle accelerators.

Some physicists argue that individual quarks may have been formed in the unimaginable explosions that marked the beginning of our universe, and there may still be stray quarks wandering about, having failed for millennia to find fellow lone quarks with which to combine.

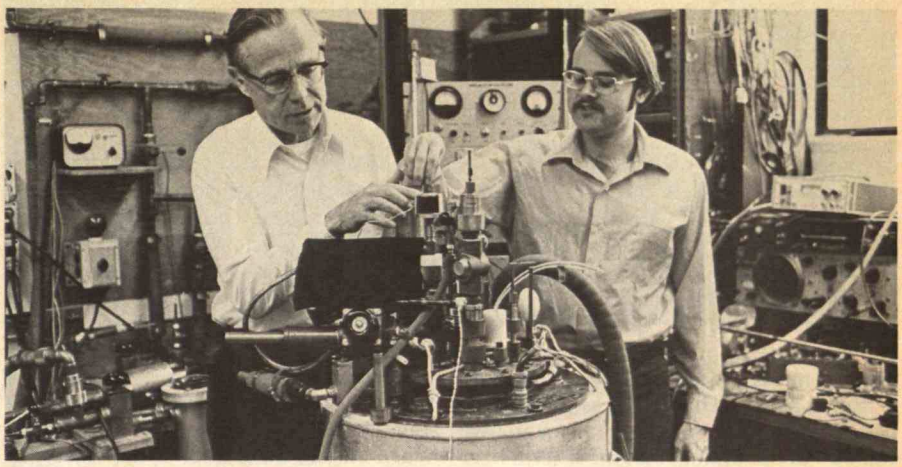
So, it was big news at the American Physical Society meeting last spring when two Stanford University scientists reported that they had detected instances of fractional charges in matter. The obvious implication was that they had "seen" a quark, for these are theoretically the only particles in nature that could possess a partial charge — plus or minus one-third or two-thirds, to be precise. Protons and electrons in contrast, possess the standard charge, set at plus or minus one.

Maybe the scientists did find the quark, maybe they didn't. But their adventure offers us an interesting lesson in the ways of science and the media. The press conference was packed, not only with science writers, but with scientists who had stolen in to hear more about the discovery that had enticed them when the official paper was given.

Some reporters were disgruntled, because the release data had been preempted by a national newsmagazine — a serious breach of professional etiquette, especially considering that the discovery was a prime chunk of news.

The senior scientist, William Fairbank, began the news conference by explaining the basis of his experiments. The research project had been going on since 1965 under various doctoral students, he said. The scientists had searched for fractional charges on chunks of material using a modification of the "Millikan oil drop experiment" of the 1900s, in which physicist Robert Millikan measured for the first time the charge on an electron. Dr. Millikan had suspended oil drops between parallel capacitor plates, measuring the voltage required to suspend the droplet in the electric field against gravity. He found that the voltages varied by integral numbers, and thereby extrapolated to the fundamental charge of a single electron.

Dr. Fairbank and graduate student George S. LaRue, however, sought the quark on much larger niobium balls — 10 million times heavier than the oil drop. (Quarks are rare, so the larger the amount of material that can be examined, the better.) They suspended the quarter-millimeter-diameter balls by floating them on



Professor William Fairbank (left) and graduate student George LaRue display the apparatus used to search for a partial charge on matter — the signature, perhaps, of the elusive quark.

a magnetic field, between two capacitor plates. By watching how the balls moved in the electric field created by the plates, they could calculate the amount of negative or positive charge on the balls. Slowly, carefully, the experimenters reduced the charge on a ball by bombarding it with positive or negative particles emitted by radioactive substances. These particles neutralized the extra positive or negative charges on a ball, so the scientists could bring the ball to precise electrical neutrality.

Or try to. On two of eight niobium balls tested in the painstaking experiments, a charge of one-third was left over — one a negative charge, and one a positive charge. The niobium ball with the negative one-third charge went "quarkless" soon after the experiment, and the scientists speculate that the quark may have been resting on the surface of the ball and was lost upon handling. The balls were transferred by a paint brush dipped in alcohol, and Mr. LaRue speculated that somewhere in that alcohol lies the escaped quark. Or perhaps the lone quark finally found a mate and merged into a neutral state.

But the other ball has kept its one-third charge since last February.

Scientists at the meeting were interested, but skeptical. Many physical quantities in nature involve the magic fraction one-third, and the scientists may have been measuring something other than charge on matter. However, Dr. Fairbank asserted, "After carefully examining these possibilities, we are satisfied that 'spurious' forces could not have caused the effect."

After the explanation of the experiment, the massed science writers began their questions. Where were the little balls now? questioned one reporter. "I keep them in little glass bottles," said Mr. LaRue, to considerable laughter. It was absurd. One did not keep materials in such important and serious experiments in "little glass bottles." Perhaps "small-volume fused silicon containers," but not "little glass bottles."

Nor did much attention rest on the other, more human details of the story of the discovery. Mr. LaRue performed his experiments at night, for even a door slam down the hall could ruin their delicate balance. There was night after night of setting up experiments, cooling the little balls to −452°C, so they would be superconducting and float upon the magnetic field, and tedious measurements.

Then one morning there was the early drive home after a night of experimentation. Mr. LaRue had obtained a one-third charge on one ball, and was sorting the problem out in his mind. Suddenly he realized what he had found in the experiment, excitedly turned the car around and headed back to the lab. Soon he called Dr. Fairbank with the news, and the two were off and analyzing.

The reporters, however, had straight news stories to write. They asked the eternal question all science reporters are paid to ask.

"Is there any practical application of your finding?"

After some reluctant hedging, Dr. Fairbank modestly allowed that the discovery of the quark would totally revolutionize physics and chemistry. Partially charged material, if it could be purified, would have a different chemistry and physics, opening a whole new world of science.

Another reporter: "Is there any military significance to your work?" Visions of quark bombs, quark rays, quark bullets . . . .

The scientists will continue their work to verify their discovery, as will other scientists in other laboratories. Perhaps their

work will mark the beginning of a revolution such as the scientific world has never seen. Perhaps it will soon be forgotten.

But the real lesson it could teach will never be learned: the lesson that science is just a bunch of turned-on people working for decades in all-night experiments with "little glass bottles" — driven by the inkling of a chance that they will discover something. This excitement was not in the dutiful press reports filed and printed on the finding, and it will seldom if ever appear in other science writing.

And the journalists aren't necessarily the real culprits. One prominent physicist recently bemoaned the fact that such an impertinent name as "quark" had been chosen for the postulated fundamental unit of matter. Wasn't dignified, he said. Wasn't serious. This business of Science had to have some grandeur about it. We can't go about joking, making it seem that research is something any human could do — for God's sake making it *accessible.*

Maybe George LaRue in his all-night experiments saw a quark; maybe he didn't. In any case, the story of his search will be reported dryly, soberly, and without exciting anybody about science. —*D.M.*

Scientists' Passports to Expertise

Any public issue of a technical nature, from nuclear power to sewage treatment, invariably sees the two sides firing "experts" at one another. It turns out that in many cases they are shooting blanks.

At the recent meeting of the American Physical Society, Bernard L. Cohen of the University of Pittsburgh bemoaned the fact that many scientists who speak out on public issues may not know any more about the issue than, say, the average cab driver, even though the public trusts them far more.

"With the present system of scientific input to public problems, any scientist can make any statement he likes. And the public has no way of differentiating whether this is a responsible statement of an expert or whether it's just some guy shooting off his mouth about something that he doesn't know anything about." said Dr. Cohen.

The two sides have developed a number of public games they play on public issues, with scientists as pawns, he said.

"There's the game of signing up Nobel Prize-winners. It seems like anytime somebody wins a Nobel Prize, people from all sides of every issue must beleaguer them. They seem to come out on all sorts of issues, including things that they don't know the first darned thing about, and aren't even interested in."

Dr. Cohen cited personal experiences with Nobel Prize-winners who, when approached for opinions on an issue, would say, "I don't know anything about it, but you can use my name."

"Then there's this game of petitions," said Dr. Cohen. "I'm sure that anybody can get any number of signatures on a petition favorable to anything." For instance, nuclear power advocates could go to a plant where jobs depend on nuclear power and gather acres of signatures on a pro-nuclear petition.

"On the other side, you have something like the recent Union of Concerned Scientists (anti-nuclear) petition, where there was a mailing out of large numbers of petitions and they got back 2,300 signatures of so-called scientists, which includes our family eye doctor, for example.

"To give you an example of what experts these people were, 17 of them were from the Pittsburgh area, and I tried to get some of them to come talk to my class. When I asked them to do it they said they didn't really know anything about it; the petition sounded all right to them so they just signed up. All they had to do was sign their name and drop it in the mail — it didn't even need postage."

Dr. Cohen proposed a testing method to make it a bit more certain that scientists speaking out on public issues knew what they were talking about.

Dr. Cohen's plan would allow any scientist speaking out on any scientifically oriented public issue to be challenged by one of his fellows. If the challenge was accepted, the issue would then go before a forum of scientists which would decide whether the issue was a reasonable one for scientific debate. Both sides of the issue would then prepare papers laying out all the salient facts, complete with scientific references supporting each position. Each side would also exchange the papers to allow rebuttals.

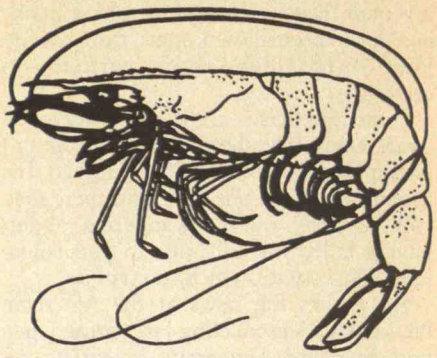
Then the scientific society would announce that the subject was coming up for judgment, and any member of the society could participate who signed a statement saying his job was not affected by the subject.

Each participant would then receive copies of the papers and rebuttals, along with a ballot and a statement to be signed that he had studied the position papers. After the ballots were tallied the results would be announced by the forum.

According to Dr. Cohen his plan would allow both sides of an issue to be stated in properly scientific terms, rather than in newspaper or magazine terms. Also, the public would be assured that the scientists who had participated in the judgment had read at least the position papers on the subject.

Critics of Dr. Cohen's plan pointed out that the voting method could produce a round of campaigning for one side or the other, complete with issue-clouding hoopla. Dr. Cohen defended his idea: "What's going on now is strictly ignorance being thrown around among the ignoramuses." — *D.M.*

The Great Crustacean Shell-out



Shrimp, and other crustaceans, contain a valuable substance within their shells — chitin, the raw material for a variety of new products.

As seafood lovers enjoy their crab, shrimp or lobster, bits of shells, claws, and other inedibles pile on the plates in front of them. It may be hard to believe these scraps are worth anything, but in this age of recycling there is potential even in shellfish wastes, according to Dale Hattis and Albert E. Murray, researchers for the M.I.T. Sea Grant Program. Discounting sporadic sources such as table leftovers, seafood processors may still be able to supply sufficient quantities of this raw material to create a variety of new products.

Occuring naturally in the shells of these crustaceans is a remarkable substance — chitin, a dose chemical relative of cellulosic polymers. Once extracted, it can be easily chemically modified and utilized in a number of ways.

Its most important derivative at present, chitosan, is particularly noteworthy for its molecular binding capability, making it a good collector and separator. For example, chitosan readily absorbs heavy metals from both fresh and salt water and can be used to treat industrial waste streams which often contain heavy metals. It can remove radioactive heavy elements from nuclear power plant wastes and metal contaminants from drinking water. It is currently being used, both here and in Japan, as a coagulation aid for the settling and clarification of waste waters in small sewage-treatment plants.

Possibilities for use seem limited only by imagination (and supply). Chitosan adheres to many nonmetallic substances as well, including glass, rubber, and a number of synthetic filaments, which lends itself to applications in adhesives and coatings for cotton, wood and paper.

Over the past 40 years successive waves of interest in chitin development have

created a technical literature but little sustained production. A key problem, say Drs. Hattis and Murray, has been a reluctance for processors to invest in production facilities without more knowledge of market potential, available supply and workable transportation arrangements.

Their new assessment, along with recent regulations prohibiting the dumping of untreated shellfish wastes into the sea, may add needed incentive. When large quantities of shell wastes are dumped in concentrated areas, their decomposition uses up the necessary oxygen to sustain local fish populations. Seafood processors must now seek profitable disposal or utilization of their refuse matter.

Drs. Hattis and Murray suggest a two-step plan. In the first, certain strategically located shellfish processors, drawing shell waste from their own operations, and possibly others within a 50-mile radius, would separate the loosely-bound tissue remaining in the shell and process it into a dried protein supplement for use in animal feed. The researchers suggest 23 prime locations for this drying process, with the major crab processing centers in the middle Atlantic states and shrimp processing centers on the Gulf Coast.

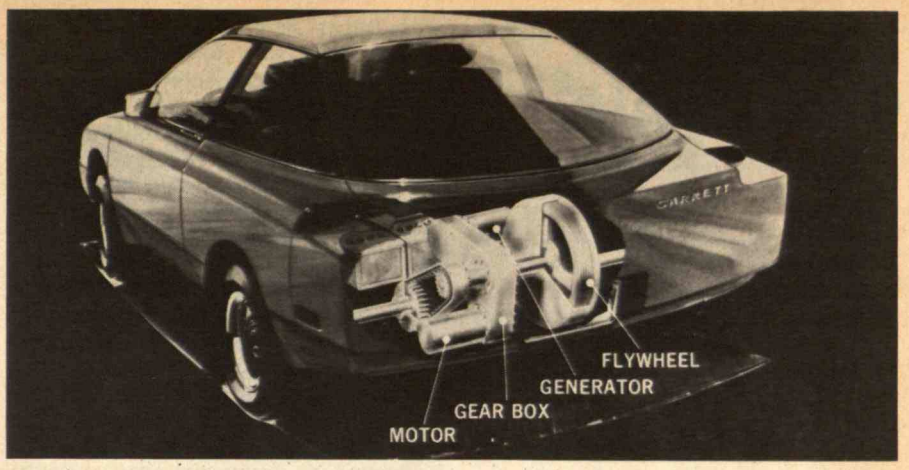
The second step of this plan would be to sell the remaining dried waste to a regional or national plant for production of chitin derivatives. Such an arrangement would solve many processors' waste problems and allow them a reasonable profit without requiring them to enter fields far outside their present expertise.

Previous estimates of potential chitin producible from shell waste in the U.S. have ranged from 25 to 100 million pounds per year, but in considering available supply of wastes, the researchers exclude those products which are marketed in the shell, imported shellfish in pre-shelled frozen blocks, and supplies out of a reasonable transportation range.

"Thus, our overall conclusion is that it appears to be commercially feasible to produce between 1 and 4 million pounds of chitin/chitosan per year for sale at a price between $1.00 and $2.50 per pound." And, they predict, it is a reasonable expectation that the market can absorb several million pounds of a cellulosic-type polymer at prices between $1.60 and $1.90 per pound. — *Sandra Knight*

Zapmobile

The electric car seems inevitable. As oil resources dwindle, it will appear far more prudent to develop an automobile powered by electricity, charged by an already-in-place power generation system, than to invest in huge plants to produce synthetic gasoline. Electric automobiles would snuggle nicely into a large, unexploited niche in the electric economy by recharging at night when electric demand is low and power plant capacity idle.



This is one of the two electric vehicles commissioned by E.R.D.A. as part of its effort to bring the electric car to practical reality.

Vehicle specifications

Length	158 in.
Width	70 in.
Height	57 in.
Wheelbase	95 in.
Curb weight	2,566 lb.
Acquisition cost	$5,000
Power system type	Hybrid electric
Cruise speed	50-55 m.p.h.
Max. speed	70 m.p.h.
Cost of ownership	15¢ per mile

But as yet electric cars have proven abysmal technical failures. For example, in its 1975 tests of two electric cars on the market, *Consumer Reports* magazine found "major safety and operating problems." The cars performed poorly, not even living up to their modestly advertised abilities. They accelerated sluggishly, balked at hills, and petered out at inopportune times. The magazine declared that "it would be foolhardy to drive either car on any public road." The electric cars now on the market have a range of only about 30 miles at 50 miles per hour, with 0-to-30 acceleration times of about 12 seconds. What's more, the cars were not significantly cheaper to run than comparable gasoline-powered subcompacts.

Two test electric vehicles recently commissioned by the Energy Research and Development Administration could mark some resurgence for the electric car. Although the new vehicles promise modest performance and rely upon better energy management technologies rather than more advanced battery systems, they could outdistance past vehicles on cost and performance.

The two electric car versions are being built for E.R.D.A. by General Electric Co. and AiResearch Manufacturing Co. Both vehicles will possess about the same range and performance characteristics — 70 miles between charges, 60-mile-an-hour speeds, and 0-to-30 m.p.h. in about eight seconds. They will also both be about the size and weight of a conventional subcompact, and will operate for about the same costs as conventional cars.

The two cars will accomplish the new performance objectives in different ways. The AiResearch vehicle will rely on a flywheel energy storage system spun up by the energy of braking, and tapped for extra energy to accelerate or climb hills. This energy load-leveling system will reduce the severe drain on the batteries upon acceleration, which has until now hindered the electric car's performance.

The General Electric car will use recovered braking energy to charge the batteries, the process being governed by an electrically controlled power conditioning unit. When brakes are applied, the electric motor will automatically become a generator, simultaneously braking the wheels and charging the batteries. This power conditioning unit will regulate power flow from the battery to control the speed of the motor smoothly and efficiently. Both cars will use on-board microcomputers to manage the energy flow from the batteries to the motor efficiently; for example, providing energy-efficient acceleration.

Officials at E.R.D.A. expect the two cars' performance to help the electric car become an acceptable commuting vehicle in a few years, even using today's relatively low-efficiency lead-acid batteries. The high-energy batteries expected in about a decade should improve performance even further. Even the E.R.D.A. electric cars must overcome many safety and operating obstacles, however. For example, *Consumer Reports* cited the hazards of sulfuric acid spilling from ruptured batteries in the event of an accident. And the magazine's engineers discovered that during cold weather battery performance plummeted, rendering the electric cars they tested practically useless. — *D.M.*

Books and Comments

Lost in the Stars

The Stars Belong to Everyone
Helen Sawyer Hogg
New York: Doubleday & Co., Inc., 1976,
x + 274 pp.; $12.50

Reviewed by Martha Hazen Liller

Helen Sawyer Hogg's book allows anyone with an interest and good powers of observation to find much in astronomy to enjoy — without the complicated equipment usually associated with the field. But although, as Dr. Hogg asserts, the stars can belong to everyone, the author is one of the relatively few women who have chosen astronomy as a profession and achieved great success. There have certainly been many more women astronomers and astrophysicists, by percentage of the total number of people working in the field, than women physicists. But the percentage is not large and has been declining steadily over the past few decades. A small increase in the last few years reflects the fact that fewer men are entering astronomy because of the tightening job market, while the number of entering women remains the same.

Why is it that, while women account for only 2 per cent of all physicists with doctorates in the U.S., they make up about 10 per cent of the astronomers and astrophysicists? In other words, why have women been given somewhat more acceptance and encouragement in these latter fields than in physics?

The answer perhaps lies in two circumstances. First, astronomy through the first several decades of this century was a more descriptive, less quantitative science than physics. Girls from an early age are victims of the "girls can't do math" syndrome. They are told, openly or subtly, that if they try math they will not succeed, and, even worse, they will lose their femininity. By the time they reach college, women are usually far behind their brothers in the math skills that they would need to become successful physical scientists. However, during the first half of this century, one could do much useful astronomy with rather simple mathematics. Thus, while physics was closed to the undertrained woman, astronomy was not.

Second, there were a few early role models and a few male astronomers who accepted their female colleagues and encouraged them. Perhaps the best known woman astronomer was Maria Mitchell (1818-1889), whose discovery of a bright comet in 1847 brought her fame, and whose teaching at Vassar College inspired many young women. Annie Cannon (1863-1941) and Henrietta Leavitt (1868-1921) were the best known of many women who worked under E. C. Pickering, Director of the Harvard College Observatory during the late 19th and early 20th century. While it is generally accepted that Professor Pickering hired women because he could pay them lower wages than men, he assigned his women assistants sophisticated tasks, and permitted them to receive full credit for their work — much of which still stands as basic reference material today. When a graduate astronomy department was formally opened in 1927 at Harvard and Radcliffe Colleges, Professor Pickering's successor, Harlow Shapley, encouraged women to enter degree programs. Three of the first five doctorates awarded went to women. One of these women was author Helen Sawyer Hogg. Another was Cecilia Payne-Gaposchkin, the first woman to attain a professorship at Harvard by working her way up through the ranks. Over the years since that time, about 12 per cent of doctorates awarded by Radcliffe and Harvard in the fields of astronomy and astrophysics have been to women. In contrast are two other institutions with major astronomy and astrophysics graduate programs: Princeton and California Institute of Technology. Until relatively recently, neither admitted women for graduate work, and neither has to date turned out many women Ph.D.s.

Equal Work, Equal Pay

Once the Ph.D. is obtained, are the 10 per cent of astronomers and astrophysicists who are women treated as the equals of their male counterparts? The answer must be a resounding "no." Two recent reports bear witness. The first, written in 1973, is the "Report to the Council of the American Astronomical Society (A.A.S.) from the Working Group on the Status of Women in Astronomy" (*Bulletin of the American Astronomical Society*, 6, 1974). The second is a paper entitled "Covert Discrimination and Women in the Sciences: The Individual and the Institution," written by Elske V. P. Smith and presented to the American Association of the Advancement of Science (A.A.A.S.) Symposium on Covert Discrimination in Denver in December, 1976 (to be published in the Symposium proceedings).

The first report asserts that the average woman astronomer holds a less prestigious position than the average male; receives a lower salary at an equal stage in her career; is less likely to be appointed or elected to offices, committees, or honors in the Society and to journal editorships. The A.A.A.S. paper reiterates many of these discriminations, and also decries the lack of flexibility in allowing women who wish to have children to proceed in their careers at a slower pace without stigma, and in providing responsible part-time or shared positions for both women and men.

Changes are occurring, if slowly. For the first time the President of the A.A.S. is a woman, E. Margaret Burbidge, and the most distinguished of the Society awards, the Russell Lectureship, was presented this year to a woman, Professor Payne-Gaposchkin. But of the 114 assistant, associate, and full professors listed by the American Institute of Physics at what are considered by many to be the top five astrophysics departments (Berkeley, Caltech, Chicago, Harvard, and Princeton), only one, an assistant professor recently denied tenure, is a woman. And the reason for this imbalance according to department chairmen is apt to be that the "pool" or percentage of women in the field is so small.

Space for Women

Clearly, if the stars are to belong to women equally with men, more change must occur. Pressure for change can be applied at many levels. Male scientists must continually be urged to support and encourage their female colleagues, and men and women alike must be mindful of the worth of the role model in persuading young women that they can succeed in the physical sciences. Women showing aptitude in quantitative subjects must from an early age be given equal encouragement to seek training that will enable them to pursue careers in astronomy and astrophysics, or other physical sciences. Girls must be convinced that they can do math and are fully capable of performing as well as boys.

Perhaps one of the more effective ways of encouraging young women in their teens and early twenties to consider careers in the physical sciences is to give them an opportunity to meet and talk with successful women in these fields. To this end, and also in celebration of International Women's Year, the Harvard-Smithsonian Center for Astrophysics, Harvard University, Radcliffe College, and the Smithsonian Institution sponsored a symposium, "The Earth in the Cosmos: Space for Women." The organizers, including this reviewer, invited several women scientists in the specialties pursued at the Center — astronomy, astrophysics, and geosciences — to tell an audience of high school and college women how and why they entered science and to describe the excitement they find in their work. There were also panels of women working

in related jobs — computer programmers, personnel officers, librarians, engineers, and secretaries — who discussed their careers. Questionnaires filled out by the audience suggest that the women who attended were enthusiastic about the opportunity to see and talk to successful women in science (many of whom have husbands and children as well), and the meeting encouraged them to consider science careers for themselves in the future. To reach even a wider audience, we gathered many of the ideas expressed at the symposium into a booklet, *Space for Women: Perspectives on Careers in Science* (available free of charge from the Publications Office, Center for Astrophysics, 60 Garden St., Cambridge, Mass. 02138). The booklet is intended as a career resource reference for high school and college women considering careers in space science.

The symposium generated sincere interest at the Center for Astrophysics in the problems that women and minorities encounter in trying to break into fields that have been dominated by white males. As a result, the Center is sponsoring a program of summer internships for high school students. Six or seven high school juniors and seniors are selected to spend the summer working (for pay) on a one-to-one basis with a Center scientist or small group of scientists. Thus the interns can become acquainted with successful scientists and can learn some of the joys, and frustrations, of working in a physical science. Anyone may apply for an internship, and active recruiting is done at inner city high schools; the rules of affirmative action govern final selection of the interns. Through the internships, we at the Center for Astrophysics hope to provide part of the support and encouragement that these high school students will need to succeed in the world of physical science.

The symposium, the booklet, and the internships are only a very small part of what needs to be done to make astronomy and astrophysics accessible on an equal basis to all. But it is our hope that they may spur action by others in a position to counteract the still strong though subtle pressures on young women to avoid fields based on mathematics and quantitative reasoning. Someday, perhaps, the stars *will* belong to everyone. Then women, equally with men, will be free to study and enjoy the wonders of the universe described in Dr. Hogg's most interesting book.

Martha Hazen Liller received her doctorate in astronomy from the University of Michigan. She is curator of Harvard College Observatory's collection of astronomical photographs, and is conducting research on variable stars and globular clusters.

The American Dream Machine

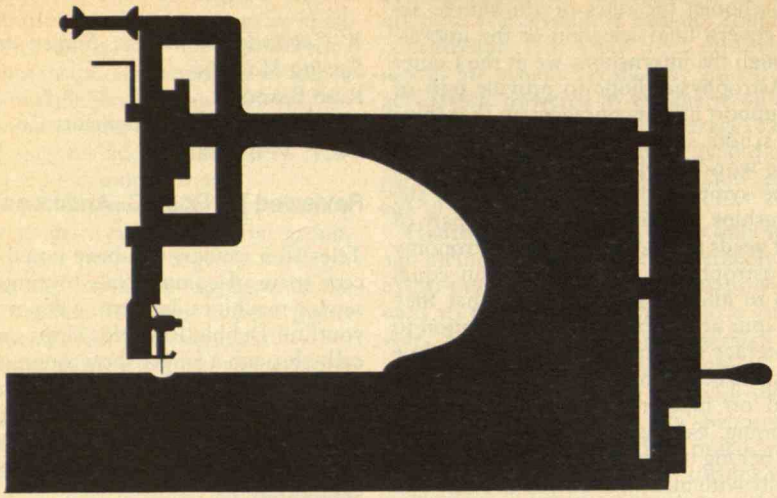
A Capitalist Romance: Singer and the Sewing Machine
Ruth Brandon
Philadelphia: J. B. Lippincott Co., 1977, xiii + 244pp; $10

Reviewed by Ross C. Anderson

Television viewers will have noted the recent spate of commercials touting Singer sewing machines. In them, a determinedly youthful Debbie Reynolds skips energetically through a Singer showroom, genially introducing us to a variety of models, commenting on each of their special attributes, and slyly suggesting that the most expensive model is indeed the one we should buy.

Debbie is dressed rather plainly for a movie star, her make-up and hairdo are less than striking, and she talks to us amicably, her voice full of sympathy. Hardly the glamorous and temperamental actress with whom we're familiar, she reminds us instead of our more likeable next-door neighbors — helpful, but not pushy; attractive, but modest and unassuming.

The domestication of fabled movie-



stars for the purpose of advertising consumer goods is a tradition, but for a product such as the sewing machine this ploy is particularly suitable. In an increasingly feminist age, the sewing machine seems more and more a symbol of traditional housewifely values. Obviously you have to stay at home to use it and it saves money on wardrobe expenses. But more than that, it is a contraption that one associates with women whose thoughts rarely travel too far from the dwellings over which they preside.

For women such as these, the image of a singularly unalluring Debbie Reynolds giving friendly advice on the tube is potent. Her ordinary mien and unprepossessing appearance suggest that she has renounced her worldly ways. Having rejected the false glitter of show business, she has settled down to the pious activity of taking care of her family — an activity which the traditional housewife instinctively knows to be the only proper way of life to begin with. If in an earlier decade she might have envied Debbie's acting ability, her snappy singing and dancing, not to mention her seductive appeal, the housewife is now reassured of her own position. Debbie Reynolds has belatedly asked to join *her* club, Debbie respects *her*, and she is flattered. So why not make Debbie happy and purchase a Singer machine?

Father Knows Best

The Singer ad campaign is not without irony, for when Isaac Merritt Singer first began to market his machine for domestic use in 1856, it was viewed not as an essential possession of the compleat mother, but rather as an instrument of liberation. No longer would a woman have to labor interminably over her family's clothes; with the aid of a new machine she could get the job done in less than half the time. But the logic of making such a purchase was by no means obvious to the consumer in 1856. First, a machine was expensive, costing $125 when the average family income was $500 a year. This problem was mostly solved by an innovative practice now common among retailers: the machine was rented to the housewife, with the rental fee (montly installments of $3 to $5) applied to the purchase price.

Psychological barriers had to be overcome, as well, before the sewing machine could gain popular acceptance. Such an extravagant purchase must necessarily be approved by the husband, who earned the money to pay for it. Why should *he* shell out funds when his wife was the only one to benefit? And once she put it to use, what was she going to do with her spare time?

To allay any husbandly fears that such a convenience would encourage idle amusements and subsequent moral degeneration, a Singer pamphlet speculated otherwise: "The great importance of the sewing machine is in its influence upon the home; in the countless hours it has added to women's leisure for rest and refinement; in the increase of time and opportunity for that early training of children, for lack of which so many pitiful wrecks are strewn along the shore of life; in the numberless avenues it has opened for women's employment; and in the comforts it has brought within the reach of all, which could formerly be attained only by the wealthy few."

A responsible husband and father could scarcely object to *that*.

There was also speculation that a woman was incapable of operating such a complicated machine. To prove otherwise Singer set women to operating his machines in places where the public would take notice — for instance, in a window on the street under the company offices, where an attractive young lady is said to have provided great entertainment to the crowd.

But even if a woman could afford and learn to operate a machine, there was still some doubt as to whether this was an activity a respectable matron could comfortably perform. Acutely aware of this attitude (though naturally not sympathetic to it), Singer's partner, Edward Clark, published an appeal addressed to ministers of all denominations offering a substantial discount if only their wives would deign to use it. These women, many of them with large families and not much money, didn't hesitate to take the company up on its offer.

Singers From Paris to Rio

As Ruth Brandon's biography shows, it was not the sewing machine itself, but the business practices surrounding its production that were responsible for its success. While Singer can be credited with designing the most efficient model of its day, Elias Howe owned the patent for it. Not being successful at marketing the invention himself, Howe happily offered patent rights to all who would buy, so Singer had many competitors.

What finally put Singer's product in the lead was his company's domination of the European market, where sales during the Civil War (when nobody back home was worrying about household conveniences) kept business thriving. Other sewing machines were available abroad, but usually through an agent who handled several lines. Singer and Co. established their own agent — in Paris, Glasgow, even Rio de Janeiro — and began manufacturing their machines abroad, as well, thus assuring maximum profits.

A discussion of the economics of Singer's empire makes surprisingly interesting reading; more frankly sensational is Ms. Brandon's account of his personal life. On August 7, 1860, the woman known to the world as Singer's wife was taking a drive in her carriage along Fifth Avenue when she happened to meet her husband coming the other way — accompanied by another woman. Suspicious of Singer's fidelity, she promptly threw herself into a tantrum, thus attracting the attention not only of Singer but of everyone else within earshot. When she reached home, Singer was there waiting for her and proceeded to beat her unconscious.

The incident would surely have been forgotten if it hadn't provoked still more revelations. As it turned out, Singer had known the strange woman in the carriage for nine years, and had given her five children, as well as a house on Christopher Street. It further emerged that he had yet another family in Lower Manhattan that he also supported. Even stranger, the Mrs. Singer with whom he lived publicly was not legally his wife at all, even though she had shared his principle residence for 20 years. In fact, Mr. Singer's legitimate family lived on Long Island, and a son from that union was an agent for the company.

The details surrounding this state of affairs are difficult to keep in order, but Singer seemed to have had no difficulty actually living the experience. Throughout the 1850s he succeeded in juggling his

time among his various households, and every child was acknowledged and well cared for. Nor did he neglect his business, for during this era he developed and continued to improve his sewing machine.

When the versatility of his domestic life became known, life grew troublesome. He retired to Europe, relinquishing an active role in the business. He married again and eventually settled in England in 1870, building himself a large house and apparently reconciled to a monogamous existence. Life was agreeable there but not long; Singer caught a chill and died in 1875.

Singer's elaborate personal history is a far cry from the apotheosis of domesticity represented by Debbie Reynolds in the company's advertising. Yet there is a consistency to it all, for in spite of the number of Singer's households, they were all conducted with traditional sex roles intact. Singer enjoyed his freedom, but his women didn't.

And he certainly didn't develop his machines for humanitarian purposes. In fact, when first approached with the idea of starting a company, he was skeptical. "What a devilish machine!" he said. "You want to do away with the only thing that keeps women quiet, their sewing!"

Ross C. Anderson studied history and history of art at Princeton University and in the graduate school of Harvard University.

Norman

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education at many institutions.

Drs. Smith and Karlesky suggest that those trends are already becoming apparent, and they are likely to accelerate unless there is a dramatic change in funding and general support for academic science — a change they believe unlikely. The immediate question is whether the potential stratification of university research, with fewer top-rank research and graduate education centers, would necessarily be cause for alarm. If it is, what can be done about it?

"Ph.D. programs in the 1960s perhaps overexpanded, and some of the research undertaken a decade ago was of less than first-rank quality," Drs. Smith and Karlesky acknowledge. Some belt-tightening and adjustment to a more austere funding environment may therefore be beneficial. In fact, according to the authors' findings, good scientists in good universities have been able to continue with their work and in most cases have managed to obtain adequate support. So far, therefore, the system of awarding grants and contracts according to scientific merit seems to have worked well. Nevertheless, "there is a legitimate concern that the erosion may have proceeded too far and may have left the nation with too few centers of scientific excellence," Drs. Smith and Karlesky warn. "The competitive pressures in a system can . . . operate quite effectively with, say, 50 strong departments competing for research funds in a certain field in contrast to twice that number. But could such competitive pressures work equally well if there were only 15 serious producers of quality research in a given field?" they ask.

Drs. Smith and Karlesky offer few prescriptions for arresting or reversing the trend. Their report is essentially designed to highlight the problems and draw attention to their possible consequences. (The budget for basic research in fiscal year 1978, proposed by the Ford administration, offers a healthy increase. Parts of the budget, however, are facing a tough challenge in Congress.)

Drs. Smith and Karlesky do offer this sombre suggestion: "We do see a possibility of a potentially serious decline in research capability before the problem emerges as a public issue. The same momentum in science that carries the system forward in times of fluctuations of support, temporary economic down turns, and relative austerity can also work in reverse. A downward spiral, if allowed to develop, could be difficult to turn around. In this event, a costly and massive public investment would be necessary to revive a faltering system."

Colin Norman is Washington Correspondent for Nature *and writes regularly for the* Review.

Vetter

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already being built or designed. Alternate energy for transportation will be very slow in developing; even with a heroic effort in transportation research and development, we can hardly expect a measurable impact on our total transportation fleet before the year 2000. Thus gas and oil are of special importance in the period to 1985 — and even to the year 2000 — and optimal oil and gas development is a crucial requirement. Meeting that requirement depends on our ability to identify attractive geologic locations, our ability to make large capital investments, and our willingness to take risks.

To encourage risk-taking, new oil and gas, appropriately defined, should be deregulated immediately. The additional cost to consumers would not make a measurable dent in our energy cost structure by 1985, but the additional income to producers is necessary to justify maximum risk-taking in the face of current exploration costs. Oil and gas should be deregulated over as short a period as possible, in any case no more than five years. If we are concerned about "windfall profits," let us adopt legislation which assures that these incremental monies are devoted to additional exploration and development effort.

Much of the potentially attractive sedimentary basins of the U.S. are under federal jurisdiction — on shore and off our coastlines. Federal and state bureaucracies and many special-interest groups have contrived to stifle vigorous exploration in these areas. We need to streamline the regulatory and licensing process, particularly of the federal government.

The coal and nuclear options face two hurdles: the availability of capital, and regulatory shackles. There will be enormous front-end costs for the development of these resources, and these heavy capital investments can be recovered only gradually through increased rates. For example, conversion to coal of *existing* gas-fueled electric generating plants could cost as much as $30 billion excluding the additional land needed or any special scrubbing equipment to meet environmental regulations. Add the needed doubling of electric generation by the year 2000 and the investments required are staggering. Consumers' payments must cover operating costs, service debt, and provide return on investment.

Little has been said here about alternate energy sources, such as solar or cogeneration. The first is still essentially in the research stage. It needs to be vigorously pursued, but one can question whether it will be of major importance until the 21st century. The second, cogeneration, holds great promise; it was once in use with considerable success in many industrial sectors. A crucial need is to study how this technology can be efficiently related to America's power grid and current industrial plant development, and the investment cost and needed incentives should be priced out in considerable detail.

One more recommendation is in order. The federal government has approached this enormously complex program with substantial inputs from technical and economic communities but with insufficient involvement of our industrial leadership. This leadership must be drafted as a full-time partner. It has a major contribution to make through experience which can best distinguish theory from probable reality.

Edward O. Vetter studied mechanical engineering at M.I.T. with the Class of 1942. He joined Texas Instruments in 1952, working for 23 years in various managerial capacities including presidency of two subsidiaries — Geophysical Service, Inc., worldwide petroleum exploration contractor, and M & C Nuclear, manufacturer of nuclear fuel — until his retirement in 1975. He was appointed Undersecretary of Commerce in 1976 and resigned in January, 1977.

How Many Buttons on the Calculator?

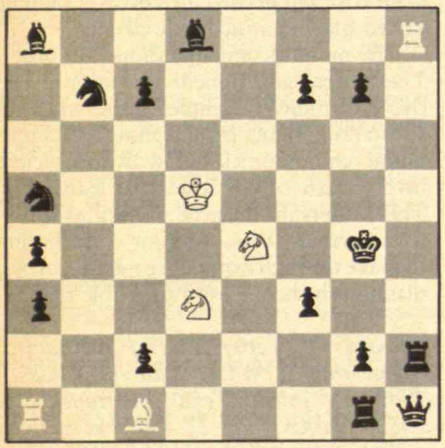
Puzzle Corner
by
Allan J. Gottlieb

As a result of a bombshell received from Frank Rubin, the "Better Late Than Never" section is rather long; so I will limit my introduction to responding to Emmet J. Duffy, who asks if a collection of problems from Puzzle Corner has ever been published. Several of our problems are old classics so have been in print prior to (and after, as well) their appearance in Puzzle Corner. However, no organized collection has appeared. If anyone wonders why, let me add that publishers are not exactly lined up outside my office begging for the opportunity.

Problems

NS-8 We start this month with an old problem that was never completely solved. The challenge, from then-tenth-grader Leslie Servi, first appeared in December, 1970:
Under what additional conditions is it true that $6N + 1$ or $6N - 1$ is prime, where N is a counting number?

J/A-1 Our first regular problem for this month is a chess offering from Bob Kimble. He claims that White can force a draw from the following position, with White to move.



J/A-2 P. V. Heftler wants you to find the smallest number which can be partitioned in six distinct positive integers such that the sum of any five of these six is a perfect square.

J/A-3 Joe Horton asks the following question about calculator design: assume a fixed number of buttons can fit on the calculator. In order to maximize the total number of functions, how many buttons should be "primary" keys and how many should be "shift" keys? (Each "primary" key gives one function if depressed alone and a different one if depressed with different "shift" keys. No more than one "shift" key may be used at once.) After you've answered the question with those rules, try lifting the last restriction.

J/A-4 Greg Jackson asks: How many times must a deck of cards be shuffled before it returns to the same order? Assume 52 cards and a perfect, nonconservative shuffle — one in which the first card on shuffle j is the second on shuffle $j + 1$.

J/A-5 Karl Kadzielski asks for an integer solution to

$$\frac{A^4 + B^4 + C^4}{A + B + C} = 39.$$

Speed Department

J/A SD-1 Emmet J. Duffy submits the following:
If i is the square root of -1, what is the square root of i?

J/A SD-2 R. E. Crandle has a circle with 256 points in its interior. Can he find a chord that divides the interior into two regions each containing 128 points?

Solutions

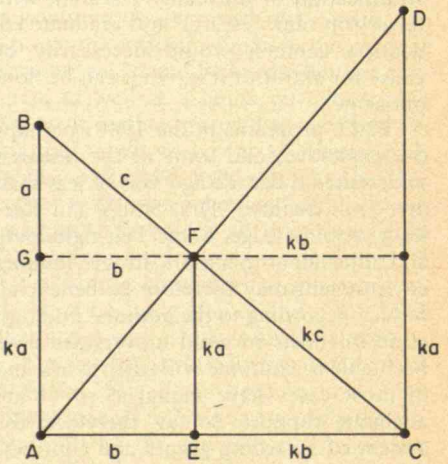
M/A-1 Rodney Yarborough, world's unluckiest bridge player, has been playing bridge for a number of years. During this period he has never received a hand worth even a single point. (Conventional point counting gives four points for each ace, three per king, two per queen, and one per jack. Also, void suits count three, singleton suits two, and doubleton suits one.) Rodney calculates that he has seen more than 1 per cent of the total number of these terrible hands. What is the minimum number of hands that Rodney has seen?

The following counting argument is courtesy of David Simen: Call a bridge hand "bad" if it is not worth any points. Such a hand has at least three cards to each suit, and only 2s through 10s may appear in the hand. All "bad" hands may be constructed as follows: throw out all jacks, queens, kings, and aces from the deck, and separate the remaining 36 cards into the four suits. Next, choose three cards from each suit; there are $\binom{9}{3} = 9!/[3!(9-3)!] = 84$ ways to choose each triple of cards, and so 84^4 ways of choosing the 12 cards. Finally, pick one card from the remaining 24 to complete the hand. There are thus $24 \cdot 84^4$ such constructions. However, we have counted each "bad" hand four times; for, given a "bad" hand, there is no way to distinguish which card of the four-card suit was the last card to be added to the hand. We conclude that the total number of bad hands is $24 \cdot 84^4/4 = 6 \cdot 84^4 = 298{,}722{,}816$; so Rodney has seen at least 2,987,229 of them. I suspect Rodney is exaggerating.

Also solved by Frank Carbin, Emmet J. Duffy, Bob Lutton, Winslow H. Hartford, Steve Grant, William Rosenfeld, Gerald Blum, R. Robinson Rowe, Richard I. Hess, Harry Zaremba, Avi Ornstein, Frank Rubin, Charlie Bahne, and the proposer, William J. Butler, Jr.

M/A-2 Given AB, CD, and EF perpendicular to AC, find any set of integers x, y, m, w, and h such that $x = \overline{CD}$, $y = \overline{AB}$, $m = \overline{AD}$, $n = \overline{BC}$, $w = \overline{AC}$, and $h = \overline{ET}$.

Many solutions are possible to this problem — even one solution with ladders of equal size. This is from Harry Zaremba:



Let the sides of triangle BGF be a, b, and c, and those of triangle FHC be k times as large. From similar triangles AFE and FDH, we have DH = ka(kb)/b = k^2a. Also, from triangle ADC, $\overline{AD}^2 = \overline{AC}^2 + \overline{DC}^2 = (b + kb)^2 + (ka + k^2a)^2$, or

$$AD^2 = (1 + k)^2(b^2 + k^2a^2).$$

The required integral distances thus become

$$\begin{aligned} x &= \overline{CD} = ka + k^2a = ka(1 + k) \\ y &= \overline{AB} = a + ka = a(1 + k) \\ m &= \overline{AD} = (1 + k)(b^2 + k^2a^2)^{\frac{1}{2}} \\ n &= \overline{BC} = c + kc = c(1 + k) \\ w &= \overline{AC} = b + kb = b(1 + k) \\ h &= \overline{EF} = ka. \end{aligned}$$

My technique to meet the problem requirements is to assume compatible integers for a, b, and c, and then, by trial, select k so that the factor $(b^2 + k^2a^2)$ in the expression for m is a square. If a, b, and c are chosen, respectively, to be 5, 12, and 13, the factor $(b^2 + k^2a^2)$ becomes a square for k = 7. Thus one set of integers for the problem conditions is

$$\begin{aligned} x &= 7 \cdot 5 + 7^2 \cdot 5 = 280 \\ y &= 5 + 7 \cdot 5 = 40 \\ m &= (1 + 7)(12^2 + 7^2 \cdot 5^2)^{\frac{1}{2}} = 296 \\ n &= 13 + 7 \cdot 13 = 104 \\ w &= 12 + 7 \cdot 12 = 96 \\ h &= 7 \cdot 5 = 35. \end{aligned}$$

Also solved by Marshall Fritz, William Rosenfield, William J. Butler, Jr., Frank Rubin, R. Robinson Rowe, Richard I. Hess, Gerald Blum, Steve Grant, Winslow H. Hartford, Bob Lutton, Edward Lynch, David Simon, Bruce Fleischer, Everett R. Leroy, Edward S. Talley, Emmet J. Duffy, Jordan S. Wouk, Harry Zantopulos, and the proposers, William F. Cheney and Norman M. Wickstrand.

M/A-3 A rural storekeeper in Georgia has a set of balance scales and a rock weighing 40 pounds. A seller from the city is passing through and he luckily has a set of conventional scales. Seizing upon this opportunity, the storekeeper desires to break his rock up so that he can weigh any exact poundage between one and 40 pounds. The city seller, however, plans to charge outrageous rates for the use of his modern scales. What is the minimum number of pieces into which the storekeeper can break his rock and still accomplish his purpose? How much would each weigh? (Rocks may be placed on either or both trays of the balance scales.)

This problem admits only one solution. As pointed out by Dan Sheingold, this technique has other applications — notably tristate electronics and ternary resistance ladders — see his note in *Analog Dialogue* 9-2 (1975). The solution is 3^0, 3^1, 3^2, 3^3 — i.e., 1, 3, 9, 27.

Also solved by Bruce Fleischer, Winslow H. Hartford, Edward S. Talley, David Simen, Edward Lynch, R. Robinson Rowe, Bob Lutton, Gerald Blum, Richard I. Hess, Frank Rubin, William J. Butler, Jr., William Rosenfeld, Harry Zaremba, Charlie Bahne, David Alan Roe, Emmet J. Duffy, Jim Inglesby, Robert Pogoff, Andrew Egendorf, Leo B. Masters, Jr., Benjamin Rouben, Naomi Markovitz, Bill Swedish, Albert H. Steinbrecher, David Gluss, Mary Lindenberg, George Flynn, Joe Lacey, Raymond Gaillard, and Harry Zantopulos.

M/A-4 Find the fourth term for each of the following related sequences: (a) 1, 20, 190; (b) 1, 21, 210; and (c) 1, 22, 231.

Andrew Egendorf, the entrepreneur behind the first pinball machine in M.I.T.'s Baker House (at which I was the star and undisputed chief crowd-pleaser), submitted the following "solution":

Jack Parsons, the proposer of this problem, will shortly be visited by the C.I.A., since the series is obviously based on the *Washington Post* coverage of the Soviet submarine recovery by Hughes' *Glomar Explorer* early in 1976. In particular, on January ("1") 20th ("20"), on page 19, headline position ("190"), it was reported that a Soviet submarine of unspecified type, code numbered 1910 ("1910"), was scooped up by the Glomar Explorer in 19,090 feet of water. The fourth (a) term is therefore 1910 [and the fifth must be 19090]. The (b) and (c) series are figured by adding the two numbers from the preceeding row which are above and above-to-the-left. The (b) code is used by East Germany, and the (c) code by Albania. The (a) code was ours.

A serious solution came from William R. Rosenfeld:
One infers immediately the three rules:

$$\begin{aligned} x_{k1} &= 1 \\ x_{k2} &= k \\ x_{k+1,l} &= x_{k,l-1} - x_{kl}, \end{aligned}$$

assuming that k = 20 for sequence (a). Not recognizing the recursion law, one uses it (with rule 2) to step back quickly to the neighborhood of k = 1. Lo! Recognition dawns! It is our old, familiar friend, Pascal's triangle! Thus $x_{kl} = ({}_{l-}{}^{k}{}_{1})$ and the three terms required are:

$\binom{20}{3} = 1140$, $\binom{21}{3} = 1330$, and $\binom{22}{3} = 1540$.

(Serious) solutions were also received from John I. Prussing, Harry Zaremba, William J. Butler, Jr., Richard I. Hess, Bob Lutton, R. Robinson Rowe, Edward Lynch, Bruce Fleischer, Winslow H. Hartford, Naomi Markovitz, Ron Greenstein, Benjamin Rouben, David Gluss, Frank Rubin, Harry Zantopulos, and the proposer, Jack Parsons.

M/A-5 Prove that the sum of the distance from any point in or on an equilateral triangle to the three sides of the triangle is constant.

The following solution was submitted by Jonathan Poritz:
This problem can be divided into three categories. In category one, the point P is in the interior of the triangle ABC and the distances to the sides AB, BC, and AC are a, b, and c, respectively. We know, from the formula ½bh, that the area of triangle ABP is equal to ax/2, where x is the length of a side of triangle ABC. This is because a would be equal in length to the altitude from P to AB. Using this method we can find the areas of triangles ABP, BCP, and ACP, which, when added together, yield the area of triangle ABC. Doing this, we find

$$\begin{aligned} (ax + bx + cx)/2 &= (x^2\sqrt{3})/4 \\ 4x(a + b + c) &= 2x^2\sqrt{3} \\ a + b + c &= (x\sqrt{3})/2. \end{aligned}$$

Since $(x\sqrt{3})/2$ will not change for a different choice of P, so also a + b + c will not change. For categories two and three, in which P is on a side or at a vertex of triangle ABC, the only different in the argument is that one or two of a, b, or c would be zero. This, of course, will still not change $(x\sqrt{3})/2$. Incidentally, this problem was assigned as homework in my ninth-grade geometry class last week.

Also solved by Ken Haruta, Morrie Gasser, Leon Bankoff, Everett R. Leroy, Robert Pogoff, Bill Swedish, Mary Lindenberg, Emmet J. Duffy, Charlie Bahne, Gerald Blum, Steve Grant, Benjamin Rouben, Winslow H. Hartford, Bruce Fleischer, R. Robinson Rowe, Bob Lutton, Richard I. Hess, William J. Butler, Jr., Harry Zaremba, John I. Prussing, William Rosenfeld, Harry Zantopulos, and Frank Rubin.

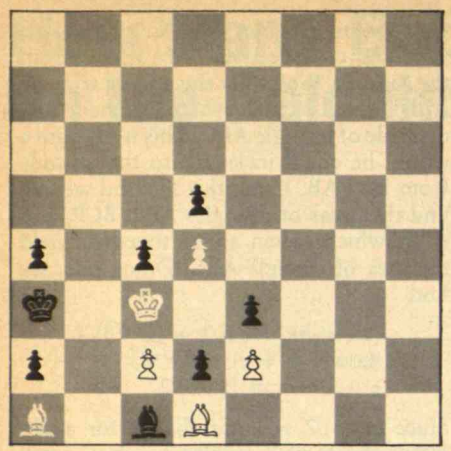
Better Late Than Never

1975 JUN-1 Responses have been received from Gerald Blum and Marc Gottlieb. Let me remind everyone that due to "technical difficulties" (*see "Better Late Than Never" in March/April*) the correct solution is Mr. Butler's published in the "Better Late Than Never" section in February, not the Chandler-Gottlieb solution published earlier in the same February issue.

1976 JUN-5 The following interesting comments are from Gerald Blum:

Your solution has both an error and a flaw. The error is that the equation should have a plus sign, not a minus. The flaw is that it is not a solution to the problem posed. The problem, as has been stated at least three times, is that "He can run twice as fast as *she* can swim." Since she is "struggling," we might resonably assume that she is not swimming — i.e., stationary. However, we know *absolutely nothing* about *his* "speed," or if he can swim at all! (If he can't, he probably should not leave the shore at all, especially if the shoreline is precipitous!) Thus the only reasonable assumption is that he can run (at the same speed) on or through the water; with this assumption, x = 50!

J/A-1 Steve Grant has a simplification of Mr. Nelson's remarkable solution as shown in the following diagram:



O/N-1 Gary Schwartz feels that a diamond should be ruffed at trick four; the revised solution (published in "Better Late Than Never" for May) does this.

O/N 4 Howard Ostar notes a typo in his published solution. The term 19y/8 should be 9y/8. Donald Barnhouse has also responded.

O/N-5 The proposer, Dr. Rubin, gives a reference for more information: "The Measure of Recognizable Sets of Real Numbers," *American Mathematical Monthly*, 83, pp. 348-49.

I received several other unconvincing responses. Mark Davidson, however submitted one I believe:

Like many questions concerning the frequency of occurrence of certain substrings of digits in decimal expansions, this is most easily handled using the ergodic theorem. Note that it is enough to show that the set of S-bounded reals in the unit interval has measure 0 since x is S-bounded if and only if x+n is S-bounded, for all integers n. Let I be the open unit interval and J be the set of all one sided sequences, $(w_1\ w_2\ w_3\ w_4 \ldots\ldots)$, where each w_i is a digit from 0 to 9. Let $X_i(x)$ be the ith digit in the decimal expansion of x. (Assume that infinitely repeated 9's are not allowed.) Then we have a map:

$\sigma: I \to J$

$\sigma(x) = (X_1(x), X_2(x), \ldots\ldots).$

If $a_1a_2a_3 \ldots a_n$ is a finite string of digits, define the cylinder set $C(a_1a_2a_3 \ldots a_n)$ to be

$\{w \in J : w_1 = a_1, w_2 = a_2, w_3 = a_3, \ldots, w_n = a_n\}.$

There is a natural measure μ on J which is determined by its value on the cylinder sets:

$\mu(C(a_1, \ldots a_n)) = 1/10^n.$

Using this measure on J and Lebesque measure on I, the map σ is an intective measure preserving map. Given a sentential digital form S, it is clear what is meant by saying that a finite string of digits has the form of S: e.g., 43562123 has the for of 4?5~3.

Let $A_S = \cup\{C(a_1 \ldots a_n)$ such that $a_1 \ldots a_n$ has the form of S$\}$. Then $\mu(A_S) > 0$. Let $T : J \to J$ be the shift to the left:

$T(w_1w_2w_3 \ldots) = (w_2w_3w_4w_5 \ldots).$

The point is that S occurs in the decimal expansion of x, starting at the ith digit, if and only if

$T^{(i-1)}[\sigma(x)] \in A_S.$

Now T is ergodic with respect to μ, and the characteristic function of A_S, X, is measurable. The ergodic theorem says that for almost all $w \in J$, as $n \to \infty$,

$$\frac{1}{n}\sum_{i=0}^{n-1} X[T^i(w)] \to \int_J X\, d\mu = \mu(A_S) > 0.$$

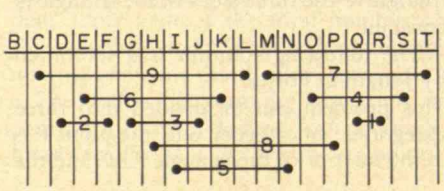
In particular, for almost all w, S occurs in the sequence infinitely often; so for almost all x, S occurs infinitely often in the decimal expansion of x, which shows that the set of S-bounded x has measure 0. Cf. Billingsley, *Ergodic Theory and Information*.

DEC-5 Morton P. Mathew has submitted the following:

The "tennis problem" answered by R. Robinson Rowe in March/April was an actual attempt by some tennis players in Winchester, Mass., to schedule their tennis matches effectively — i.e., with maximum rotation of players. I worked out "seat-of-the-pants" solutions for up to 24 players but never found a neat, general method of attack. Nonetheless, 20 regulars are playing tennis in Winchester with the following schedule: Players A through T start with match I in 5 doubles courts:

I.	AB/IN	CL/DF	EK/OS	GJ/HP	MT/QR
II.	AC/JO	DM/EG	FL/PT	etc.	
III.	AD/KP	EN/FH	etc.		

In match II, every position but A is replaced by the succeeding letter player (B by C, I by J, ... T by B). Similarly in match III. After 19 matches, every player has had every other player for a partner once and for an opponent twice. It was laboriously worked out in this way: Obviously, the alphabetic spacing of all partners must be different at the start. If D and F, and also G and I, were partners in match I, then by match IV D and F positions would be replaced respectively by E and G, then F and H, and then G and I, who were already partners in match I. To avoid this, a lot of trial and error can produce this chart with line-connected dots under letters indicating pairing of partners, all varying distances apart on the alphabetic scale (B has A for his initial partner).



So far so good. The rotation can be completed without partners repeating. It is considerably harder to complete the arrangement so that the alphabetic spacing of opponents does not repeat more than once. For example, if the starting line-up included:

$$\text{I.}\quad \frac{CL}{HP}\quad \frac{DF}{IN}\quad \frac{EK}{GJ}$$

rotation to match II would give:

$$\text{II.}\quad \frac{DM}{IQ}\quad \frac{EG}{JO}\quad \frac{FL}{HK}$$

and to match III:

$$\text{III.}\quad \frac{EN}{JR}\quad \frac{FH}{KP}\quad \frac{GM}{IL}$$

and already E has had J for an opponent three times. This was inevitable from the start, where C opposite H, D opposite I, and E opposite J were all five alphabetical steps apart. Systematic shuffling can eventually bring in the result. It can also consume untold hours. A computer program could undoubtedly handle it. But the original problem, to find a straight path to a general solution for 4n players, seems to remain.

I received a phone call from another reader suggesting that a general solution will be submitted within a month. Maybe this won't be an NS problem in the 1980s after all!

1977 JAN-2 This is starting to sound like a broken record: "The proposer, Frank Rubin, refutes the published solution." Recall that the published solution had a leading zero. Many readers (and the Editor) found this unacceptable but the best we could do; I was disappointed that a Rubin problem should have an unaesthetic solution. Now Dr. Rubin replies: I do not know whether you have changed the wording of this problem, but it would have been clearer to say, "Replace each letter by a unique digit from 0 to 9 to make a correct equation." Of course, many readers will note that there is no solution in base 10. Moving right along, there are two solutions in base 11:

$$940A98 \times 7 = 5A66A21$$

and

$$923496 \times A = 8411475$$

but both use the digit A = 10. In base 12 there are five solutions:

$$\begin{aligned} A923A5 &\times 7 = 634430B \\ 562158 &\times 9 = 4177130 \\ 412549 &\times A = 35005B6 \\ 40A847 &\times B = 3899825 \\ 64096A &\times B = 5988932 \end{aligned}$$

Of these, all but one use digits beyond 9. The only valid solution in base 12 is then

$$\begin{array}{r} 562158 \\ \times\quad 9 \\ \hline 4177130. \end{array}$$

Winthrop M. Leeds, Richard I. Hess, Kenneth L. Wise, and Gerald Blum have responded.

Proposers' Solutions to Speed Problems

J/A SD-1 In polar coordinates, i is 1 at an angle of 90°. The square root is 1 at an angle of 45°, which in rectangular coordinates is cos 45° + i (sin 45°) = $\sqrt{2}/2 + (i\sqrt{2})/2$.

J/A SD-2 (courtesy of the Editor) There are at most $\binom{256}{2}$ lines that contain two (or more) of the 256 points. Choose a line L, not parallel to any of these. Start L to the left of the circle and move it to the right parallel to itself. By construction, L crosses points one at a time. Stop after crossing 128 points.

Allan J. Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics and Coordinator of Computer Activities at York College of C.U.N.Y. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y. 11451.

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Boulding

Continued from p. 4

If we can avoid confusing the wholesale and retail, we may be able to work out policies which combine them in the right proportions, and that would be an enormous step forward.

Kenneth E. Boulding is a director of the Institute of Behavioral Science and Professor of Economics at the University of Colorado at Boulder. He is a regular contributor to the Review.

Nisbet

Continued from p. 10

labor-intensive. In response to the jibe that environmental protection opposes growth, progress, and employment, we respond that we promote growth in sectors of the economy that ought to grow. The emphasis on capital-intensive production of materials-intensive goods is the real obstacle to progress and full employment.

Ian C. T. Nisbet is Associate Director of the Scientific Staff, Massachusetts Audubon Society. He writes regularly for Technology Review.

Holt

Continued from p. 13

and wind (and perhaps wave) against the time when we will need them. We have pilot models of most such systems already.

Even if the space colonizers can do what they promise — and they can't — we hardly know how to eat and sleep in zero-gravity, let alone mine, smelt, and manufacture. Space colonies are a bad bet. Earth is the place to spend our energy money.

John Holt is a teacher and author of numerous books, most recently Instead of Education: Ways to Help People Do Things Better *(E. P. Dutton, 1976). At present, Mr. Holt is at work on what he describes as a "musical autobiography."*

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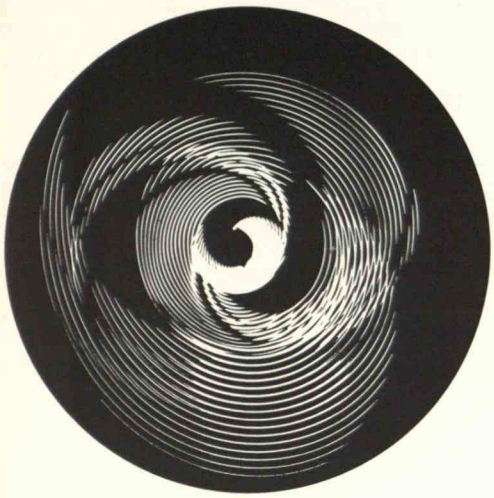

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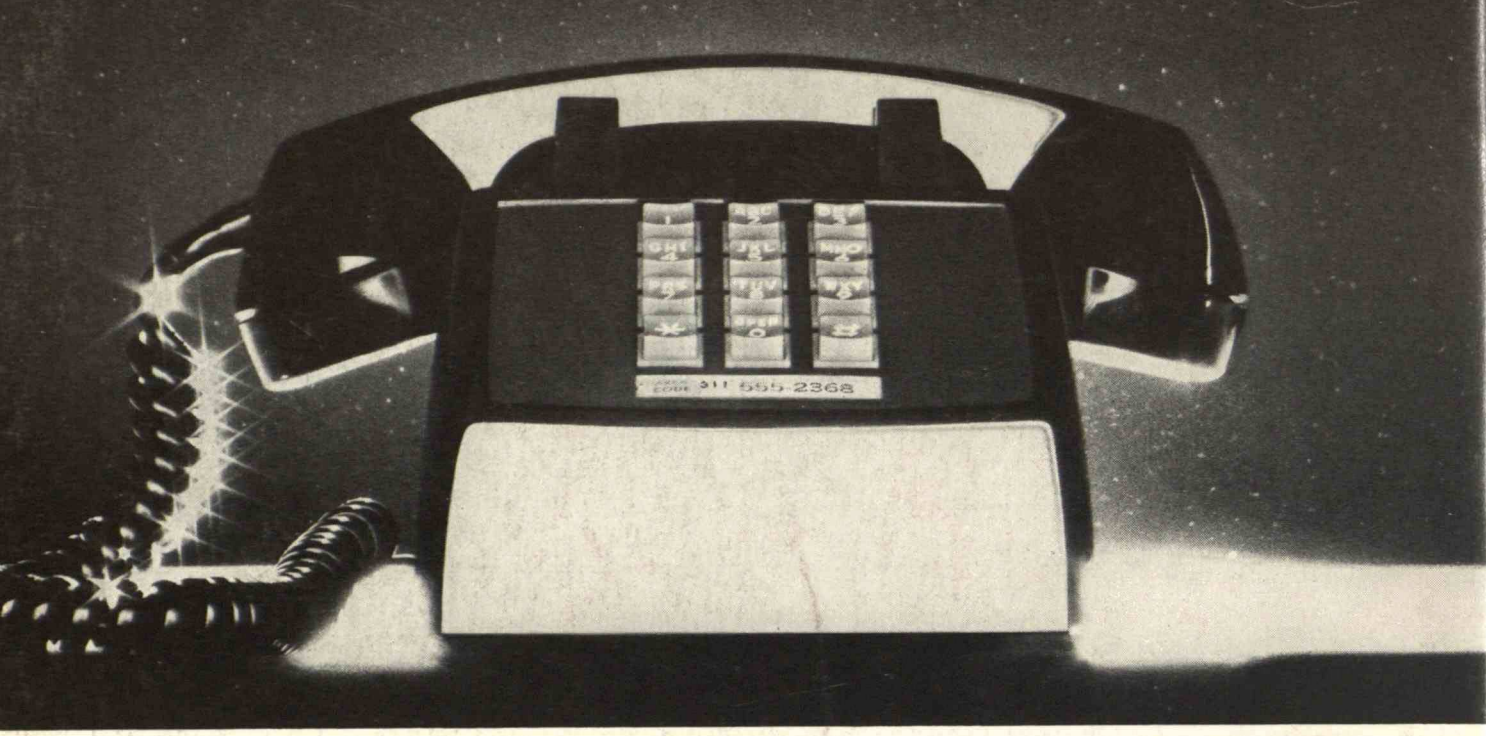

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